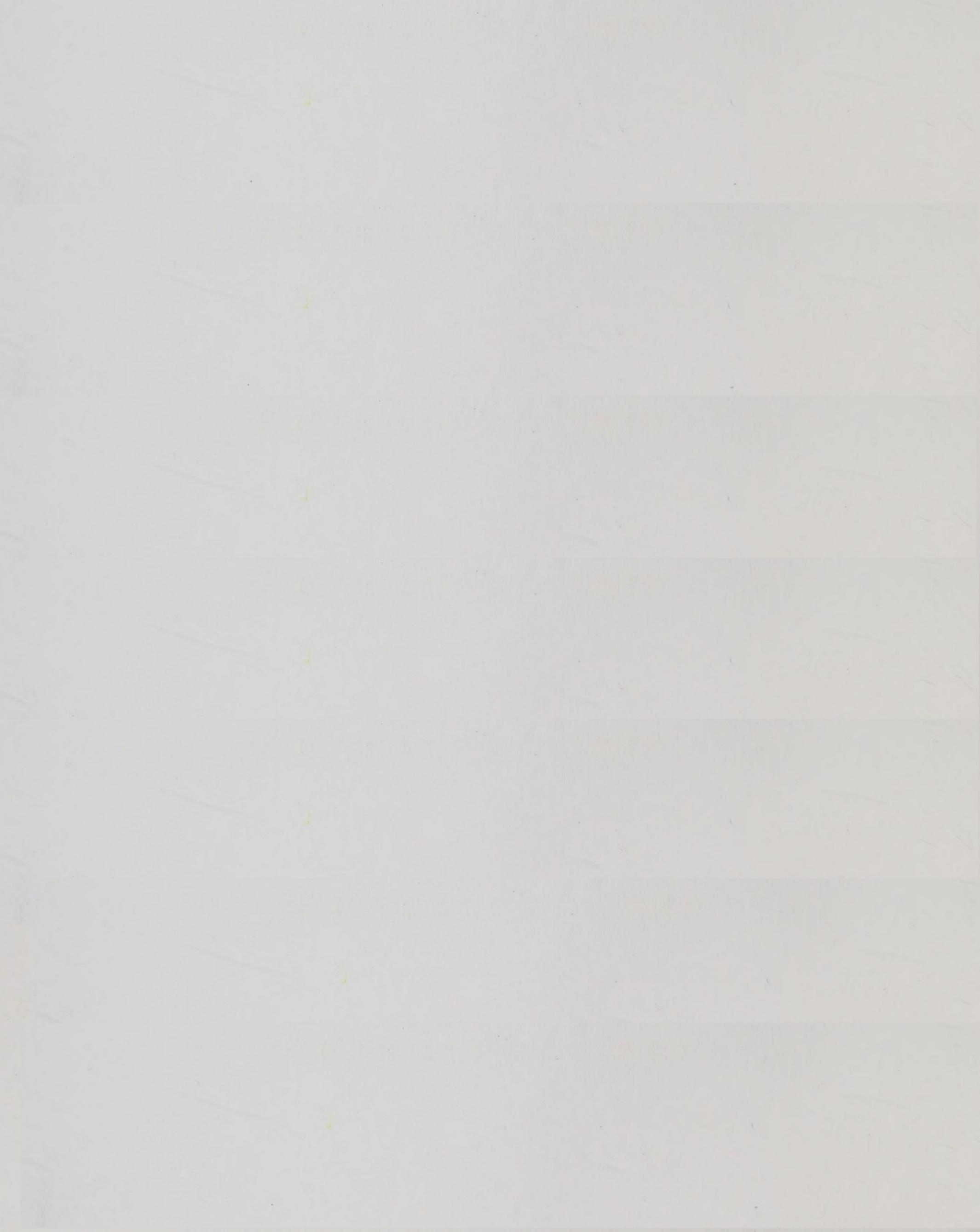
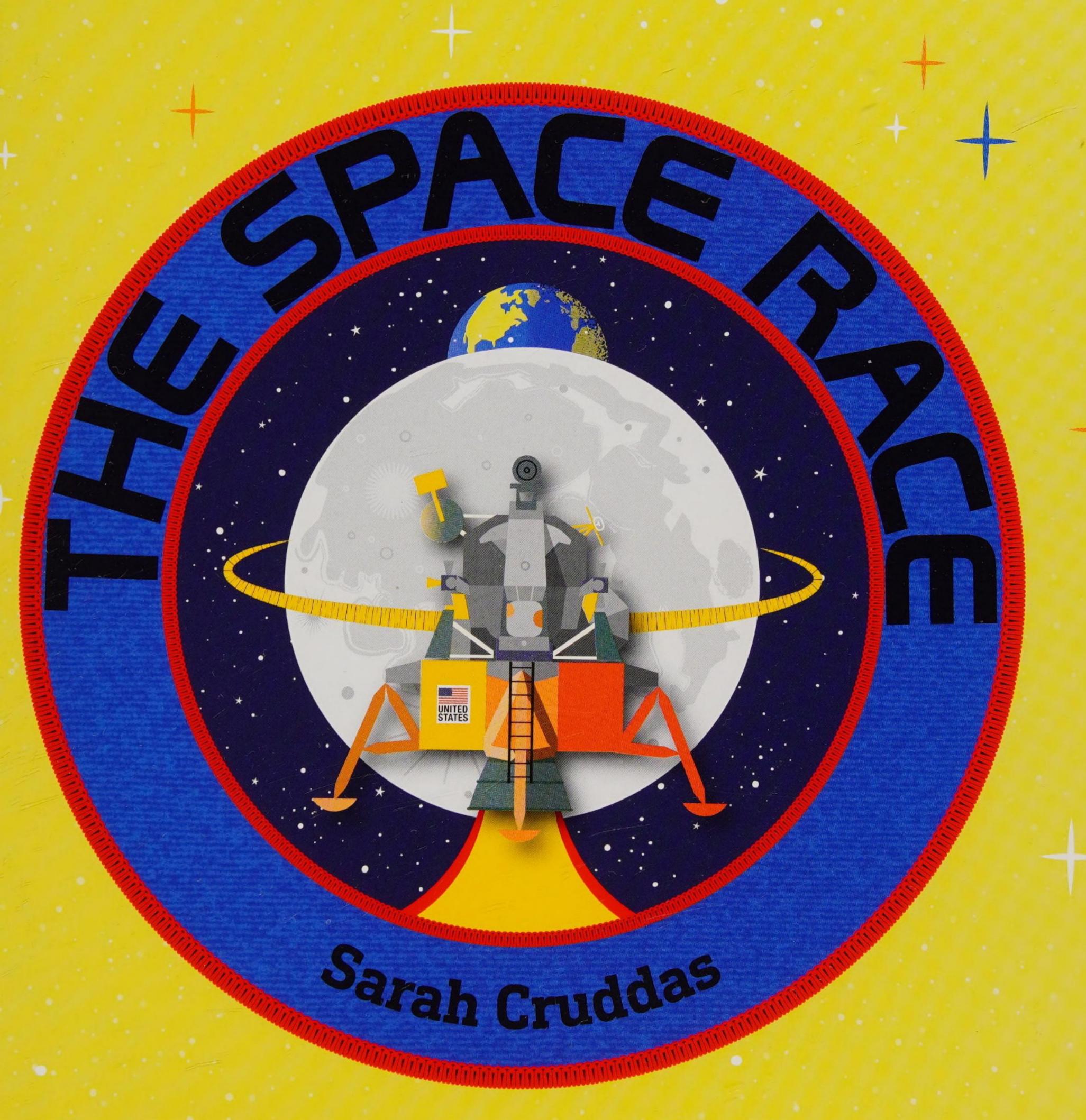


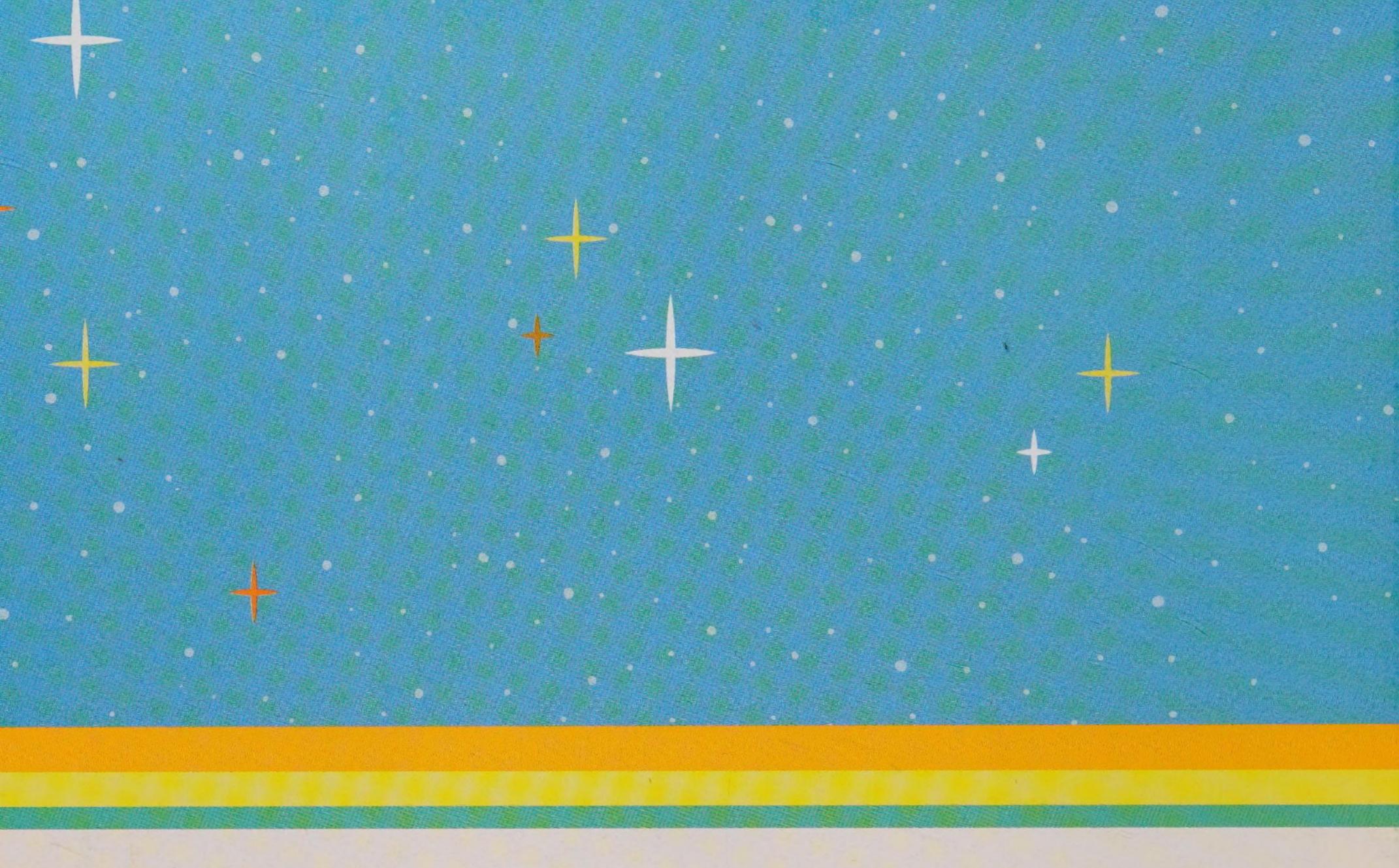
Sarah Cruddas













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A WORLD OF IDEAS: SEE ALL THERE IS TO KNOW

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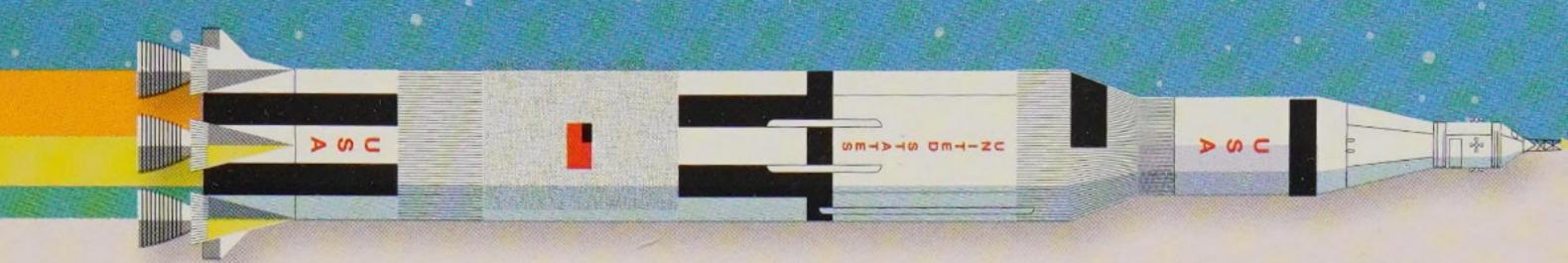
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Footsteps into space



Foreword

Being in space is awesome. It is the most amazing human experience. You can look out the window to see Earth, stretch out your arms and feel like you are flying over the planet. You can see fires burning, the wake of ships, and the different colours of the oceans. Sometimes you'll see snow, or the forest and jungles. Earth is so beautiful. But the most amazing thing is that you are floating!

I started getting interested in space when I was nine years old, reading about the Gemini astronauts during the space race. I wanted to be one of them. They were all men, but I never thought that I couldn't do it because

I was a girl. I said to myself that's what I'm going to do – I'm going to be an astronaut. It was the ultimate flying job and I have always wanted to go farther and faster and higher. When Apollo astronauts walked on the Moon, I was reading books about flying.

My family had no money but I got a job at 16 and saved up to pay for flying lessons. Later, I became one of the first women to go through pilot training with the Air Force. In those days, women weren't allowed to fly in combat, but I was asked to stay as an instructor, so I got to fly fast jets – this gave me the experience needed to go to test pilot school and apply to be an astronaut.

When I was selected as the first woman to pilot the Space Shuttle, this also meant that I would have the opportunity to be a Commander one day. I knew that commanding a space mission would be the most important job I would ever do. At NASA, I decided to work as hard as I could to be the best that I could be. It was important to me to get along with people, be a good communicator, and to help people work together to achieve the goal of the mission.

I twice flew to space as a pilot and then, in 1999, I flew my first mission as a commander. I was the first woman to ever command a Space Shuttle mission. It was a huge honour and a huge responsibility.

My advice to you is to learn about the world. To explore. That is where you will discover what you want to do with your life. Listen to your teachers, and study maths, science, and

engineering – these subjects are important for our future. Learning other languages is also important, because space exploration involves lots of countries.

I hope in the future we will see people on the surface of Mars. To get there, we will need to go back to the Moon, to test equipment. At the moment, 12 men have walked on the Moon. They did so between 1969 and 1972, but no woman has walked on the Moon. Women were certainly capable, but the culture at the time didn't allow women to do that. But we will definitely see the first woman walk on the Moon and we will see people walk on Mars.

My other hope is that we discover a way to travel faster in space, so we can go to the other planets in our Solar System and then eventually outside of our Solar System. A future discovery is awaiting us so that we will have the ability to do that. Maybe you will be part of inventing or discovering something like this in your lifetime.



Astronaut Eileen Collins
First female Space Shuttle Commander

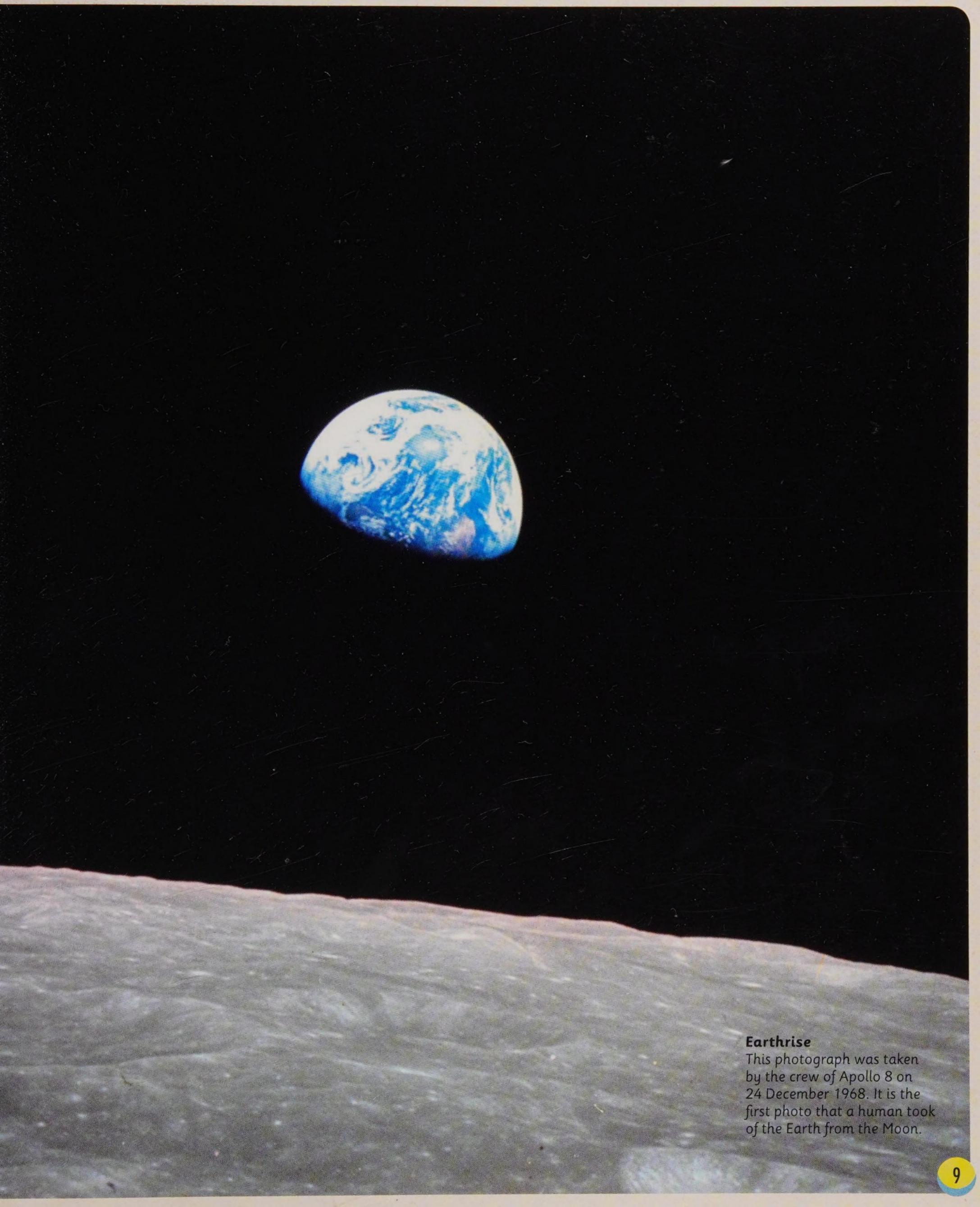
It took one photo to change the way we viewed the world forever. This is our home, planet Earth, as seen from the Moon. Everything we have ever known has existed on this blue marble in the darkness of space. Every animal, plant, and person – everything.

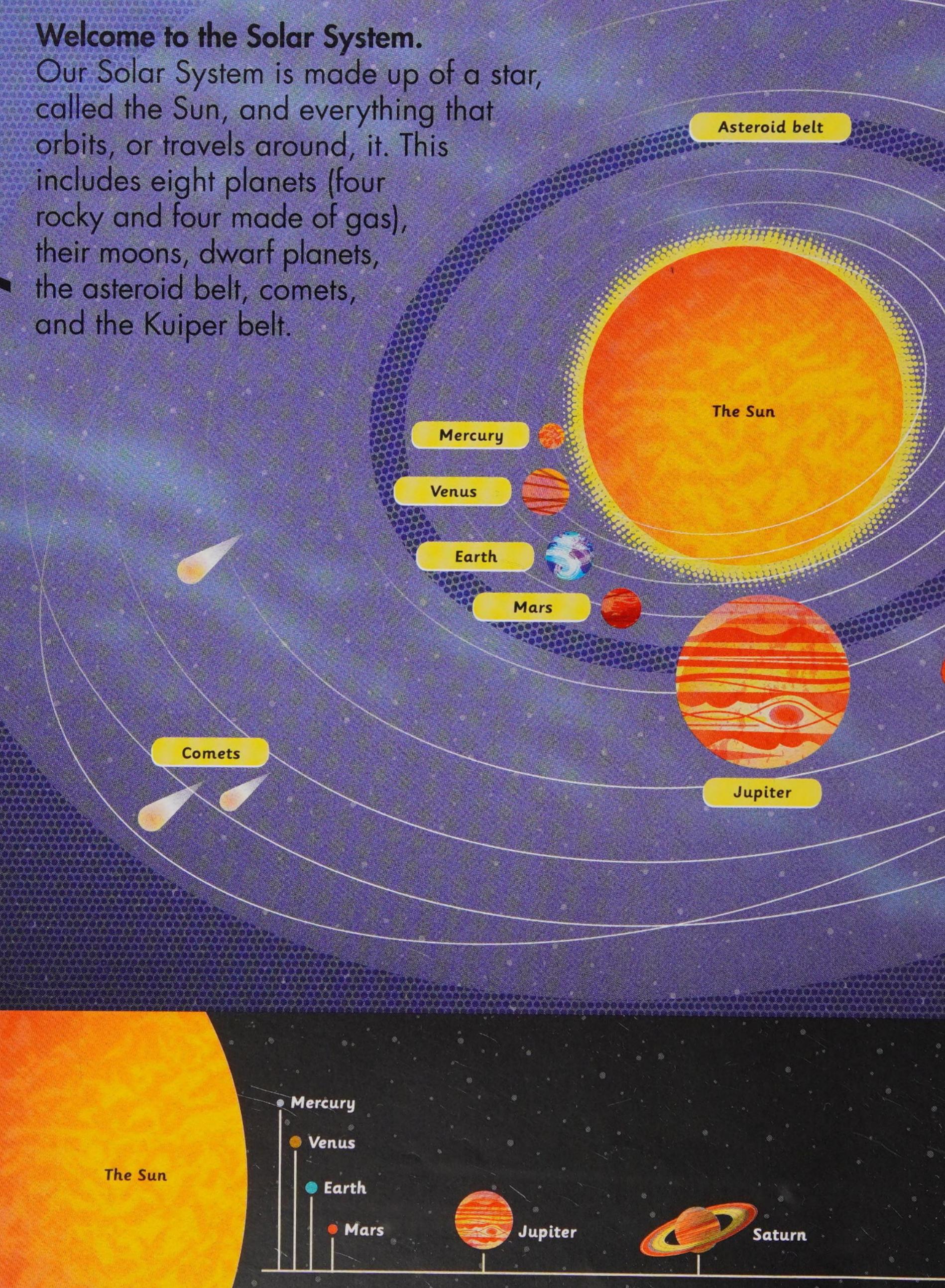
For thousands of years, people looked out to space and developed tools, such as telescopes, to learn more about what was out there. They would dream about space travel, of one day reaching the stars, but it was only in the last century that those dreams started to become a reality.

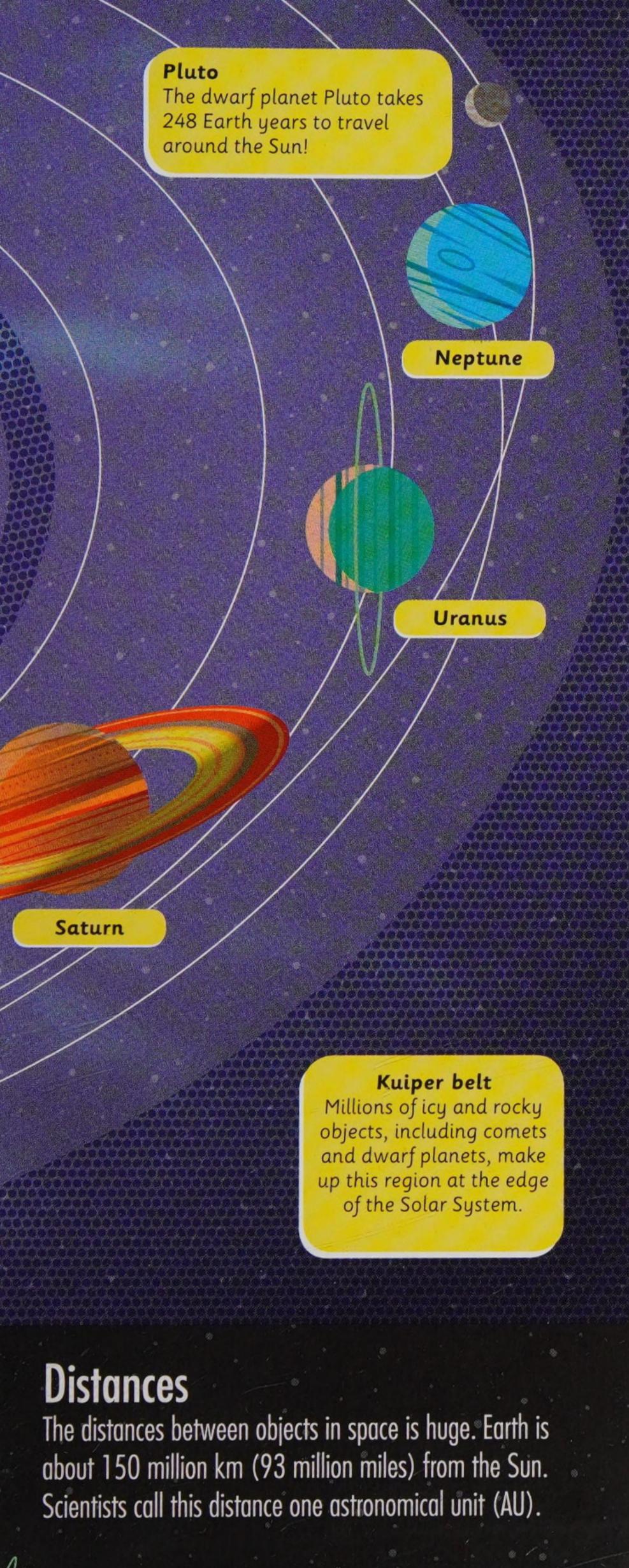
Today we live in what is known as a space age. Some humans live and work in space and we are constantly making new discoveries. Space is exciting because we still don't know about everything that's out there. However, we do know that space contains many other planets. There are likely to be millions and millions of them. They are too far away for you to see with the naked eye, and we don't know if life exists on any of them.

We went to space because we were curious. We continue to go to space because we still have many unanswered questions about our Universe.









Rocky planets

The four inner planets of our Solar System are known as rocky planets because they are mostly made of rock.



The four outer planets are the largest in our Solar System. They are mostly made of gas, so spacecraft cannot land on them.



Mercury

The closest planet to the Sun, Mercury is a scorching-hot, rocky world with no air to breathe.

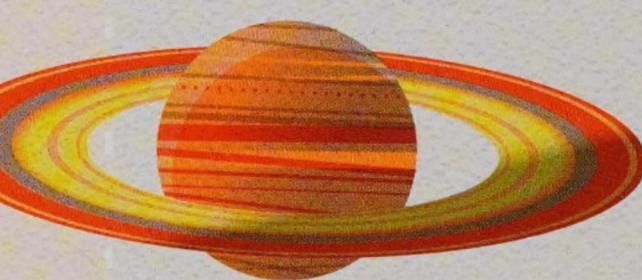


Jupiter

The biggest planet in our Solar System is so massive you could fit more than 1,300 Earths inside it!



Venus

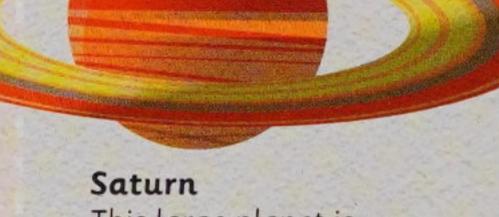


The second planet from the Sun has a chokingthick atmosphere that can crush spacecraft landing there.



Earth

Our home, Earth, is the third planet from the Sun and the fifth largest in the Solar System.

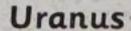


This large planet is famous for its beautiful rings, which are made of rocks and ice.



Mars

This planet is also known as the Red Planet due to the reddish rust (iron oxide) in its rocks.



The oddball of the Solar System, Uranus orbits the Sun tilted on its side.



Neptune

The furthest planet from the Sun, Neptune is also the windiest place in our Solar System.

Uranus

Our star, the Sun, is one of hundreds of billions of stars in a galaxy called the Milky Way. This galaxy is just one of many billions of galaxies in the Universe. There are so many stars and galaxies that no one would ever be able to count them all.

Solar System

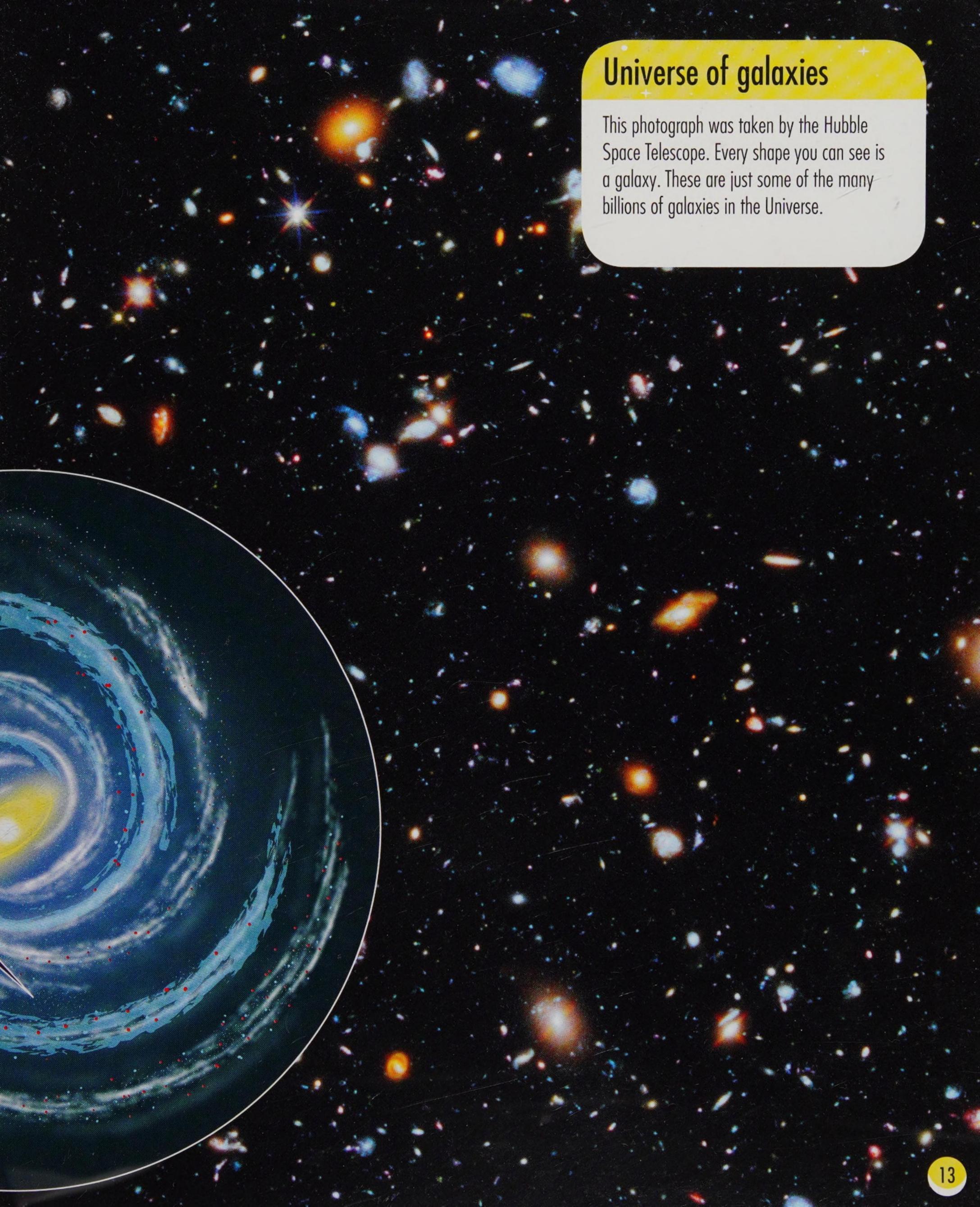
Earth is part of the Solar System. It orbits, or moves around, the Sun, which is one of many stars in the Milky Way that has planets orbiting around it.

Earth

Our planet has all the ingredients needed for life to flourish. It is the perfect distance from the Sun to be just the right temperature and to have liquid water. At the moment, it is the only place we know for sure that has life on it.

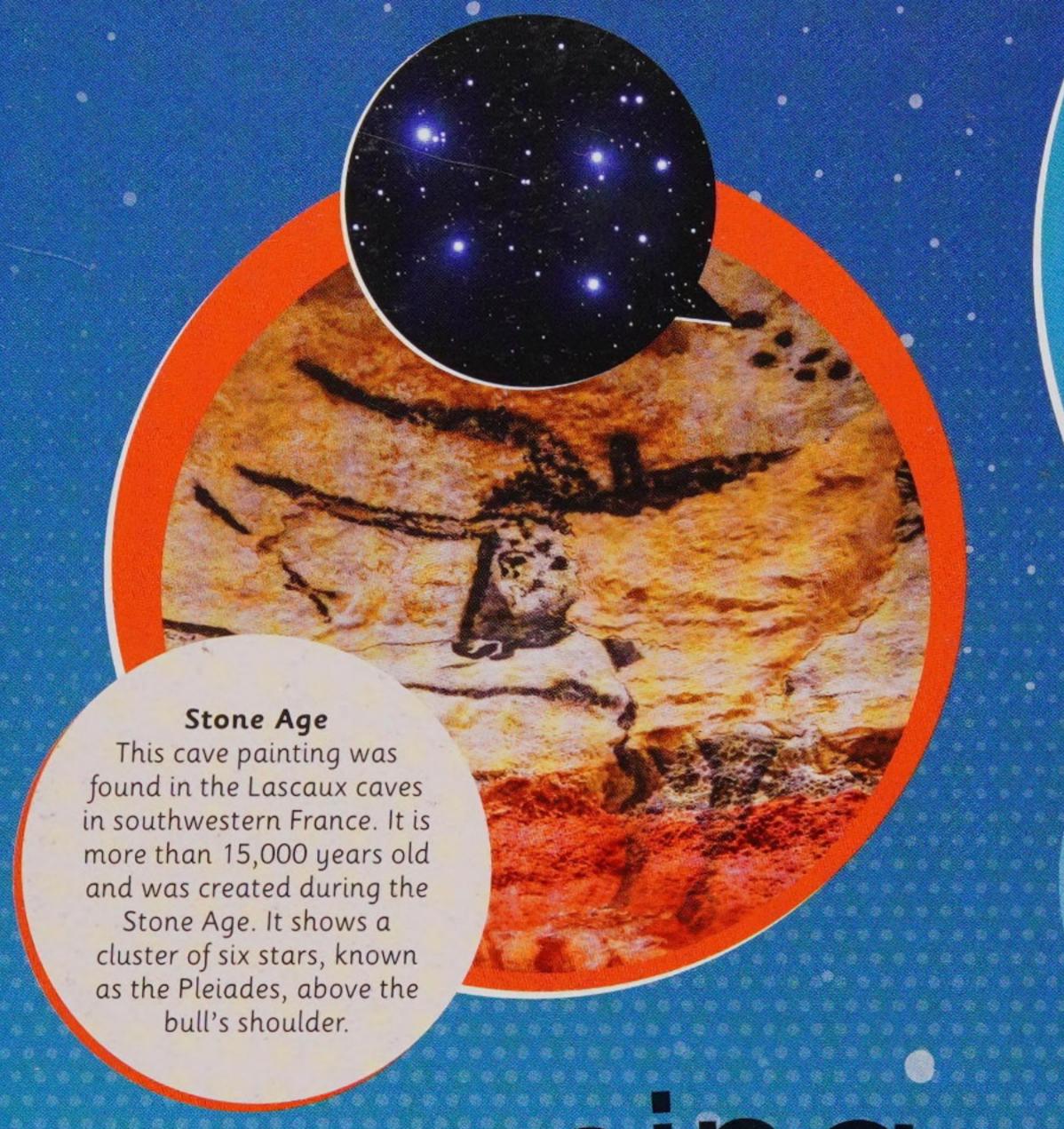
Milky Way Located in the Milky

Way's outer spiral arm, our Solar System travels around its centre — known as the galactic centre. One orbit takes about 230 million years.









Ancient Greece

The Greeks used to call planets "wanderering stars", as they looked like stars that moved across the sky.

Ancient Greek astronomers were among the first people to study our Solar System.

On a clear night, you have probably looked at the night sky frontier as we know that the night sky frontier as we know the great sky frontier as we know the great sky frontier as we know the night sky frontier

On a clear night, you have probably looked at the night sky and wondered what was out there. Humans have always been fascinated by space.

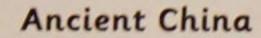
Cave paintings, thousands of years old, provide the first records of people looking at the stars. Later, astronomers began studying space and creating maps of the night sky. During the Age of Exploration (1450–1750 CE), the oceans

became the great frontier as we began to explore Earth, and sailors would use the Moon and the stars to navigate the seas.

As technology developed at the start of the 20th century, so did our dreams about space. Science-fiction writers imagined trips to the Moon and voyages to faraway worlds. However, the reality of going to space was still beyond our reach.

Star navigation

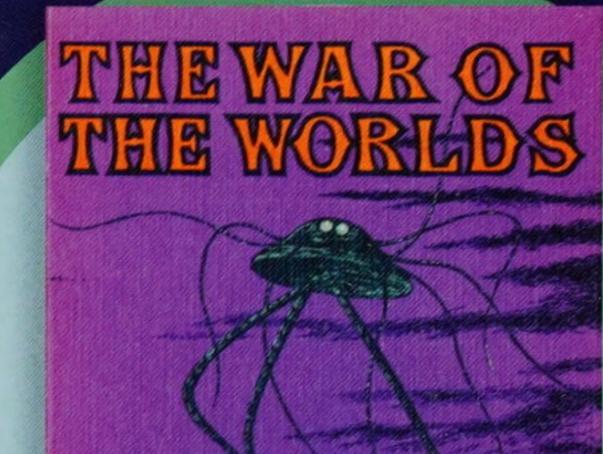
Sailors measured the positions of stars in the night sky to help them navigate. These star patterns helped sailors to work out which way was north, east, south, and west.



China has a long history of astronomy — the Chinese thought that the movement of stars in the sky showed the actions of their emperors. This Chinese star chart is the earliest known map of the night sky, and dates back to around 700 ce.

Science fiction

First published in 1898,
The War of the Worlds
by H.G. Wells captured
the public's imagination
with its tales of aliens
and space travel.



H.G.WELLS



Early dreams of space flight

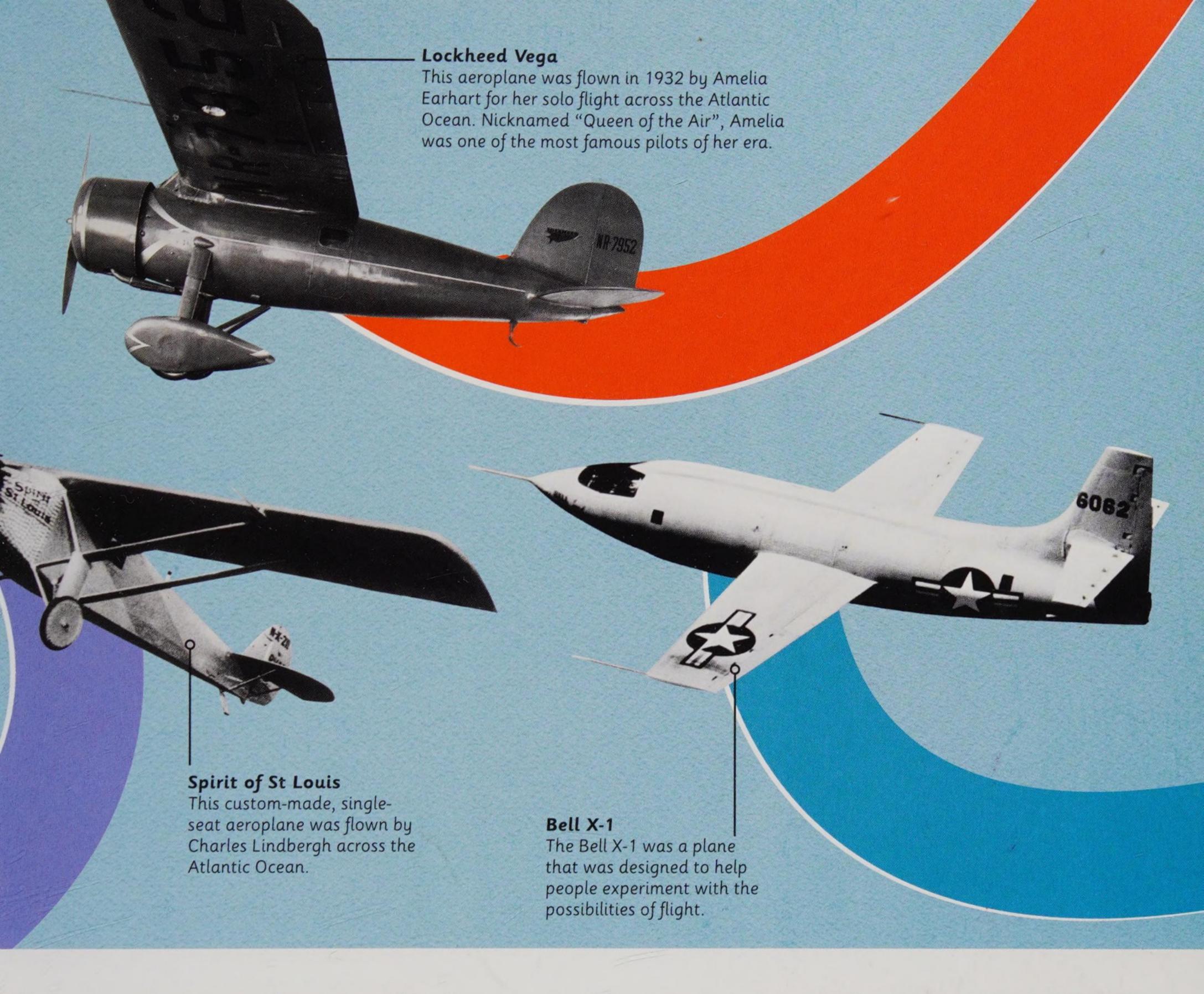
In 1902, the French film Le
Voyage dans la Lune (A Trip
to the Moon) was released.
It told the story of a group
of astronomers who were
blasted from a cannon on
Earth all the way
to the Moon.



Before we could go to space, we had to conquer the skies. Some of the earliest attempts to fly, such as wearing wings to try to copy birds, had not ended very well.

The first breakthrough came in 1783, when a sheep, a duck, and a cockerel became the first passengers on a hot-air balloon

flight. However, it wasn't until 17 December 1903 that two American brothers, Wilbur and Orville Wright, made the seemingly impossible possible. The brothers designed and flew the world's first successful aeroplane, the Wright Flyer. The first flight lasted just 12 seconds, but it inspired more people to try to fly aeroplanes.



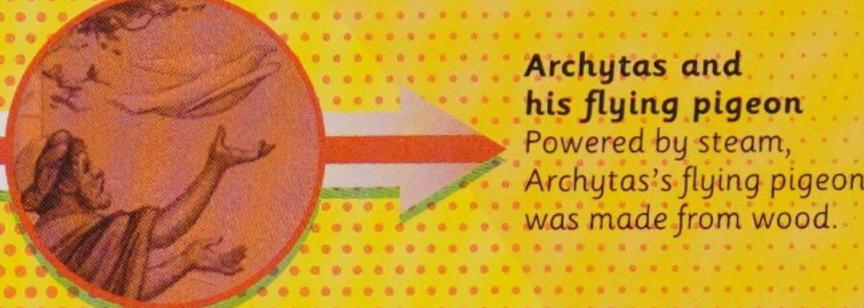
A new era in exploration had begun. In 1927, Charles Lindbergh became the first person to fly from New York to Paris by aeroplane. Then in 1932, Amelia Earhart became the first woman to fly across the Atlantic Ocean alone.

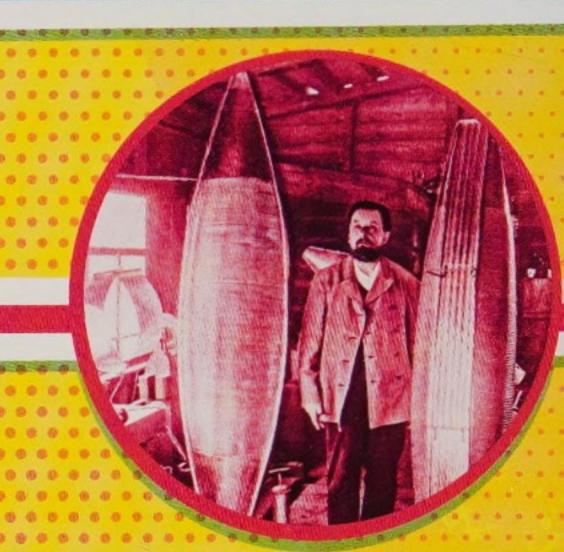
During World War II, aircraft became larger and more powerful,

as countries including the UK, USA, Germany, and Japan created new types of bomber, fighter, and transport plane. These developments led to the Bell X-1, which Chuck Yeager flew in 1947. The Bell X-1 was more like a space rocket than a plane, and it flew faster than the speed of sound! This rocket plane proved that space flight was almost a reality.

To travel to space, you need a powerful rocket.
While rockets are modern inventions, the ideas behind them are thousands of years old.

One of the first people to think about rockets was the ancient Greek scientist and philosopher Archytas. He created a steam-powered wooden pigeon in around 400 BCE, which flew along a wire for 200 m (650 ft). The first real rockets came from China, where gunpowder was invented.





Rocket power

The Chinese put gunpowder in tubes, which then fired arrows when lit. These were used in battles in around 1200 CE.

However, it was not until the start of the 20th century that scientists began to think about rockets flying to space. During World War II, engineers in Nazi Germany, led by rocket scientist Wernher von Braun, developed the V-2 rocket. This was a long-range missile that was so powerful it could travel to the edge of space.





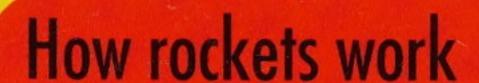
Chinese fire arrows

These worked using gunpowder, which, when lit, pushed gas, fire, and smoke out of one end to move the arrow forwards.

41-1

Konstantin Tsiolkovsky

In 1903, the maths equations needed for rocket travel were developed by the Soviet engineer Konstantin Tsiolkovsky.



The basic principles behind rockets are fairly simple. Burning rocket fuel releases gases that push the rocket skywards. To work, the rocket has a hole in the base for the gas to escape from, and a smooth, shaped top so that it can easily glide through the air and not be slowed down.

Reaction

The rocket reacts to the power of the gas being pushed out of the back by moving upwards.

Action

Pushing the gas out of the bottom of the engine makes the rocket move forwards.



In the late 1920s, American engineer Robert Goddard launched the world's first liquid-fuelled rocket. He laid the foundations for modern rocketry, and proved that rockets would be able to work in space.



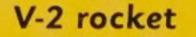
Hermann Oberth

The German physicist and engineer Hermann Oberth (centre) was inspired by science fiction. His work showed how rockets could escape the Earth's gravity.



Robert Esnault-Pelterie

In the 1930s, French engineer Robert Esnault-Pelterie experimented with different types of rocket. In one experiment he lost some of his fingers in an explosion!



First flown in 1942, the German V-2 rocket was used as a weapon in World War II. It also showed that it was possible to use a rocket to get to space.



VS

Korolev

who built the German V-2 rocket travelled east to the Soviet Union. Many others, including von Braun, the German inventor of the V-2 rocket, went to the United States. After relocating, von Braun and his team began to develop rockets for the US Army. They later moved to the newly formed National Aeronautics and Space Administration (NASA).

Meanwhile, in the Soviet Union, the efforts to get to space were led by Korolev. A rocket engineer and designer, Korolev started the Soviet space programme, leading the designs of its spacecraft. In the summer of 1955, the United States announced its plans to send a satellite into space. A few days later, the Soviet Union said it would do the same. The space race had begun.





On October 4, 1957, a silver satellite about the size of a beach ball was placed on top of a rocket and launched into space. It was the first human-made object to orbit the Earth, and to the US's dismay, it was launched by the Soviet Union. Named Sputnik—which is Russian for "traveling

companion"—the little satellite transmitted radio signals back to Earth to let people know where it was. News of the launch was greeted with both fear and wonder. People across the world worried that the launch of Sputnik could cause another world war, as there were already tensions between the US and the Soviet Union.

> However, there was also excitement as Sputnik signaled the start of the space age. It traveled around Earth for three weeks before its batteries stopped working and it could no longer send signals home. Sputnik later returned to Earth, burning

up in the atmosphere. The question on everyone's lips was, "Could people be next in space?"



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Satellite-gazers People around the world looked up at the night sky to try to spot Sputnik.

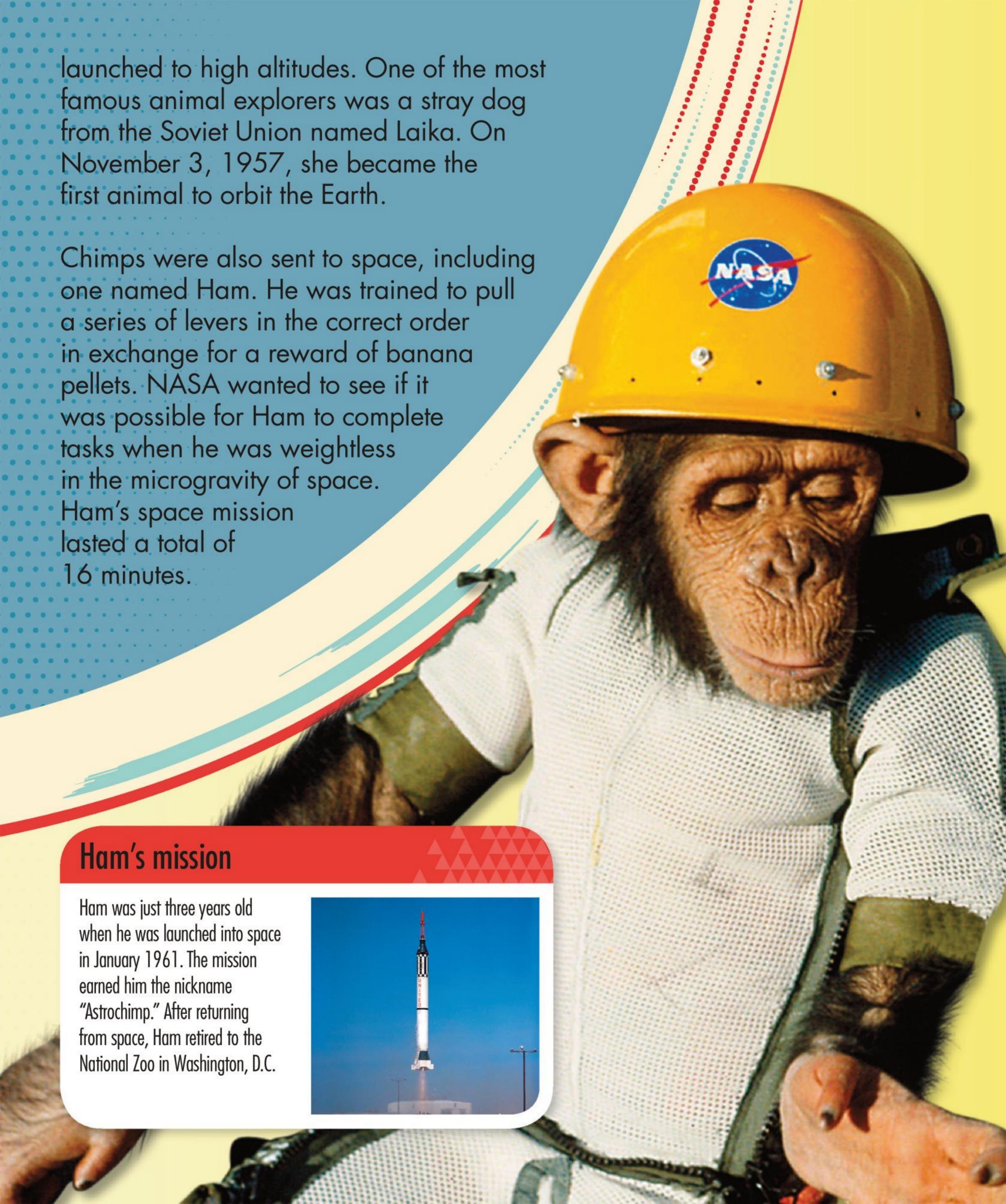




Animals paved the way for humans to go to space. Scientists did not know if a person could survive a trip to space, and if they could, what would happen to the human body.

They decided to send animals to space first, to test the impact that

space travel would have on a living being. This testing began shortly after World War II, and in 1947 the Americans used a German V-2 rocket to send fruit flies to space. During the late 1940s and early 1950s, different types of small creatures, such as mice, were



Introducing... The Mercury

Meet Alan, Gus, Gordon, Wally, Deke, John, and Scott. In 1959, they became some of the most famous people in the world—America's first astronauts, nicknamed the Mercury 7.

The Mercury 7 had been selected from a group of more than 100 elite military test pilots. They were skilled at flying different types of aircrafts and could think fast in dangerous situations. This group of seven had shown that they had what it took to go to space. They had to pass lots of tests, which were designed to reproduce what scientists thought might happen to a person who traveled to space. Also, they had to be a maximum of 5 ft 11 in (1.8 m) tall because they had to fit inside a tiny spacecraft.

Their mission was Project Mercury, the NASA program to put an astronaut in space ahead of the Soviet Union. The program was named after the Roman god Mercury, who was known for being fast. They were the best of the best, and they were now American heroes.







On April 12, 1961, there was a breakthrough in the space race. For the first time in the history of humanity, a person left Earth and traveled to space. That person was cosmonaut Yuri Gagarin, a 27-year-old fighter pilot from the Soviet Union.

That morning, Yuri had put on his spacesuit before riding a bus to the launch pad in a place called Baikonur, Kazakhstan. He climbed inside a tiny spacecraft on top of a rocket. The clock began to count down, and just before the launch Yuri yelled "poyekhali!" (In English, this means "Let's go!") Minutes later he was in space. Among those watching was rocket inventor Sergei Korolev, who was so nervous he couldn't sleep the night before.

Yuri flew around the Earth at a speed of 5 miles per second (8 km per second) and traveled more than 200 miles (320 km) above the Earth, higher than any human had ever been before. He was the first person to see Earth from space and the first person to experience being weightless—although there was not enough room to float around in his tiny spacecraft.

Launch traditions



On the day of his launch, Yuri peed on the back tires of the bus that was taking him to the launch pad! It has become a tradition for cosmonauts traveling to space from Baikonur to do the same.

One hour and 48 minutes later, and having completed one orbit of our planet, Yuri returned safely to Earth. In the Soviet Union, he was welcomed back as a hero, while the United States was in shock—they had been beaten once again.





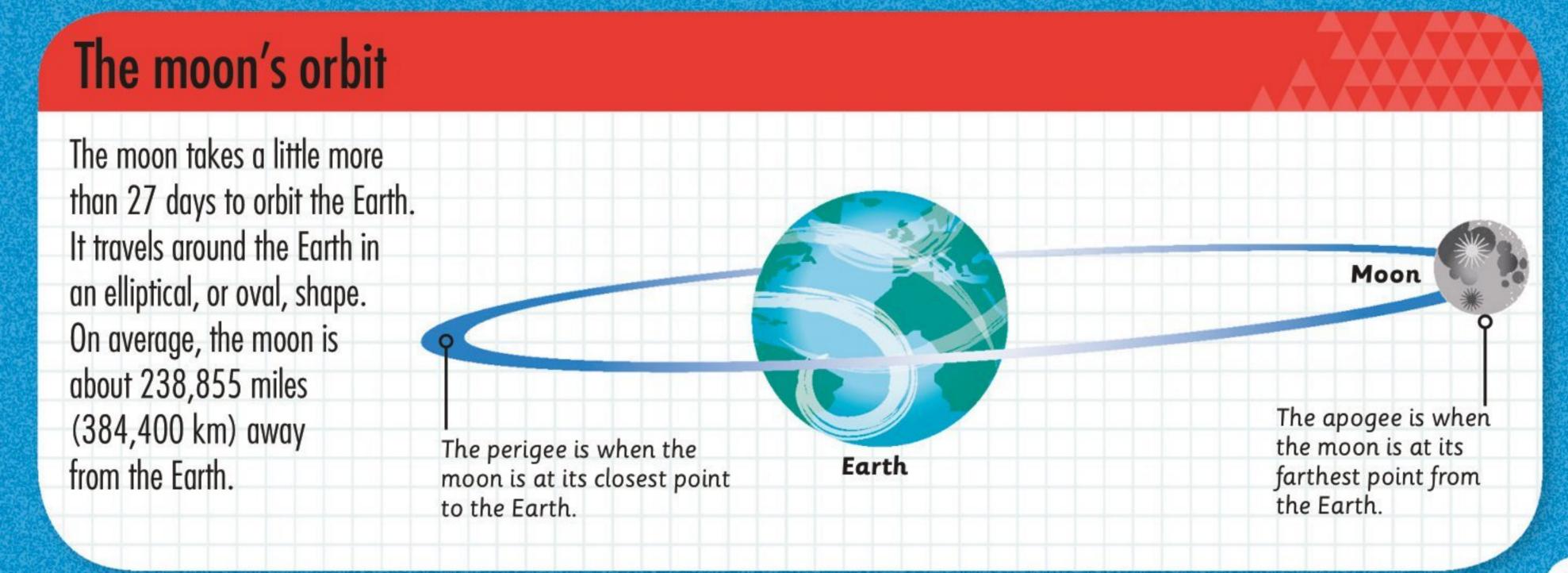
On May 25, 1961, President John F. Kennedy presented a new idea to his government. He wanted to send a human to the moon and return them safely to Earth before the end of the decade. Up to this point, the United States had only sent an astronaut into space for 15 minutes, so landing on the moon seemed almost impossible.

In September of the same year, President Kennedy gave an iconic speech to 40,000 people in Houston. He stated his goal to achieve a human moon landing before the Soviet Union. At this time, space travel was very new and mysterious. The Americans knew that the Soviet Union was leading the space race by sending the first person to space—Yuri Gagarin—

and so something extraordinary had to be done to get ahead.

President Kennedy came up with the idea of going to the moon because it was something that the Soviet Union could not do with their existing rockets. The United States had advanced spacecraft technology, and NASA confirmed that President Kennedy's goal was achievable.

Leading rocket designer Wernher von Braun now had the chance to make his dream of sending humans farther into space a reality. Along with a huge team at NASA, and other engineers across the country, von Braun took on the difficult task of designing the rocket that would take the first humans to the moon.







Training for space

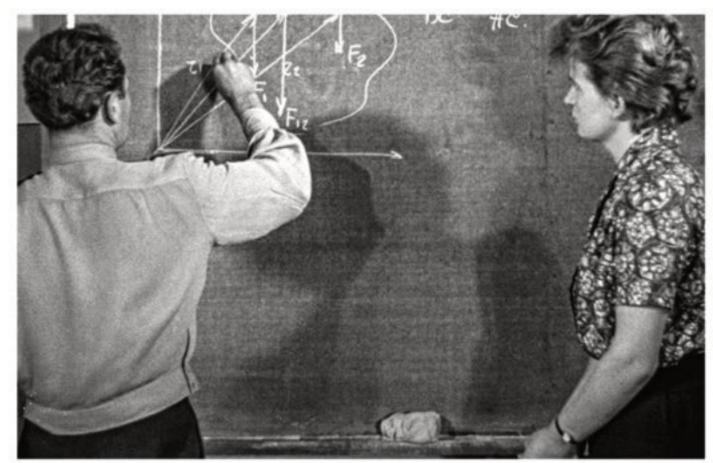
It took 18 months for Valentina to be ready for her spaceflight. She had to undergo lots of training, including tests to see how well she would cope with being on her own in space.



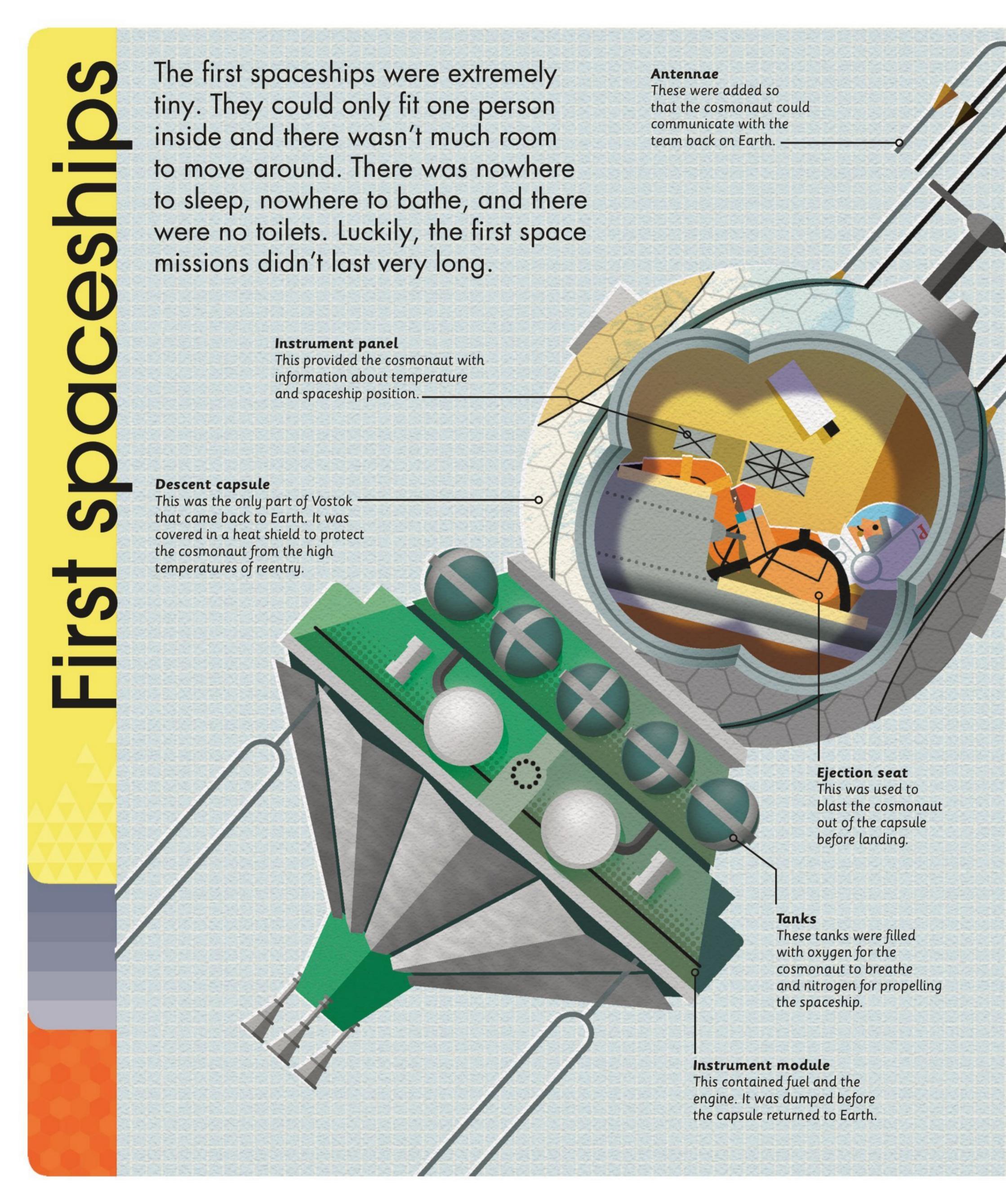
Valentina was hooked up to machines for health checks.



This spinning frame (gyroscope) produced a sensation similar to tumbling in space.



Valentina studied engineering to learn how space rockets worked.



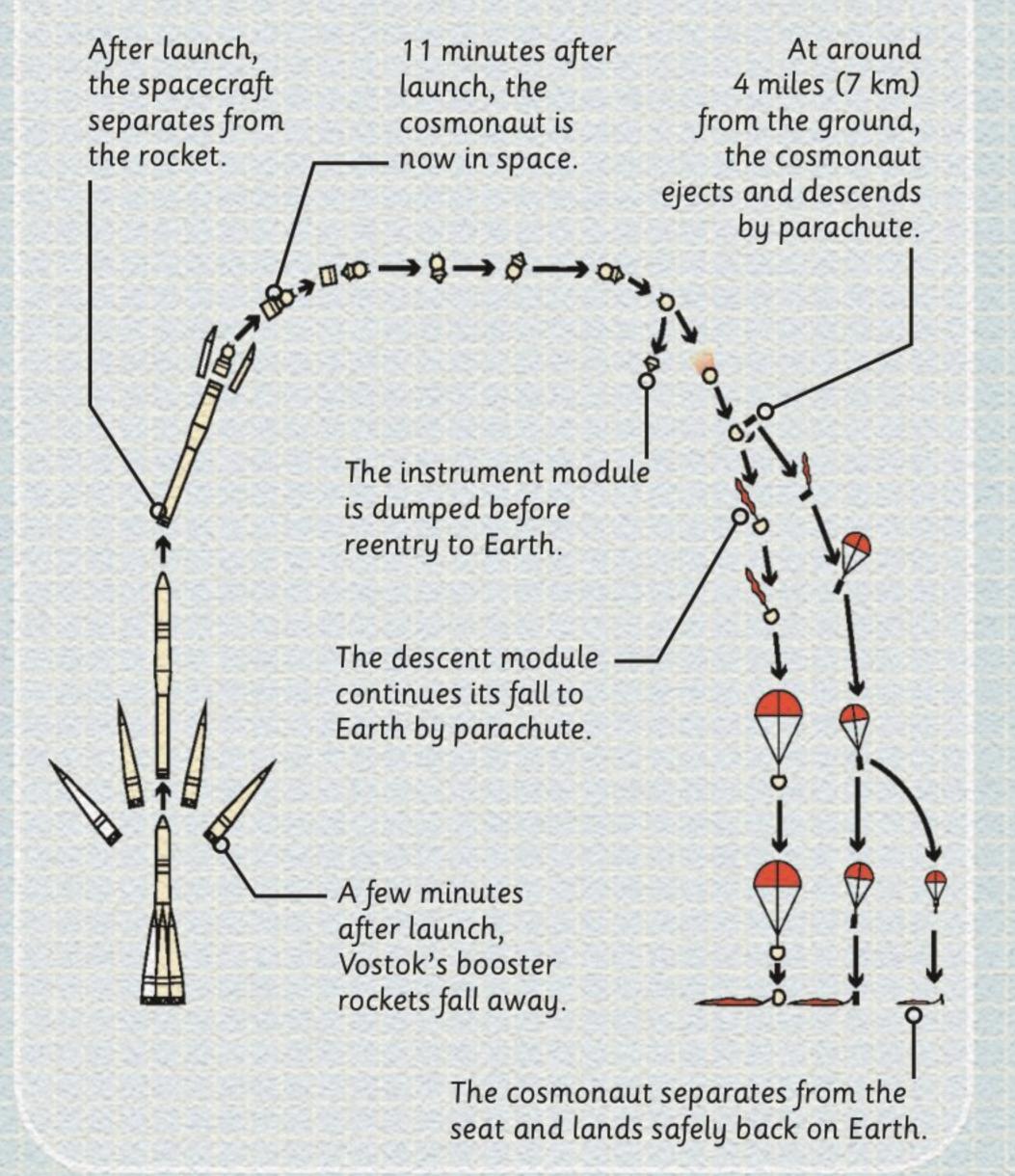


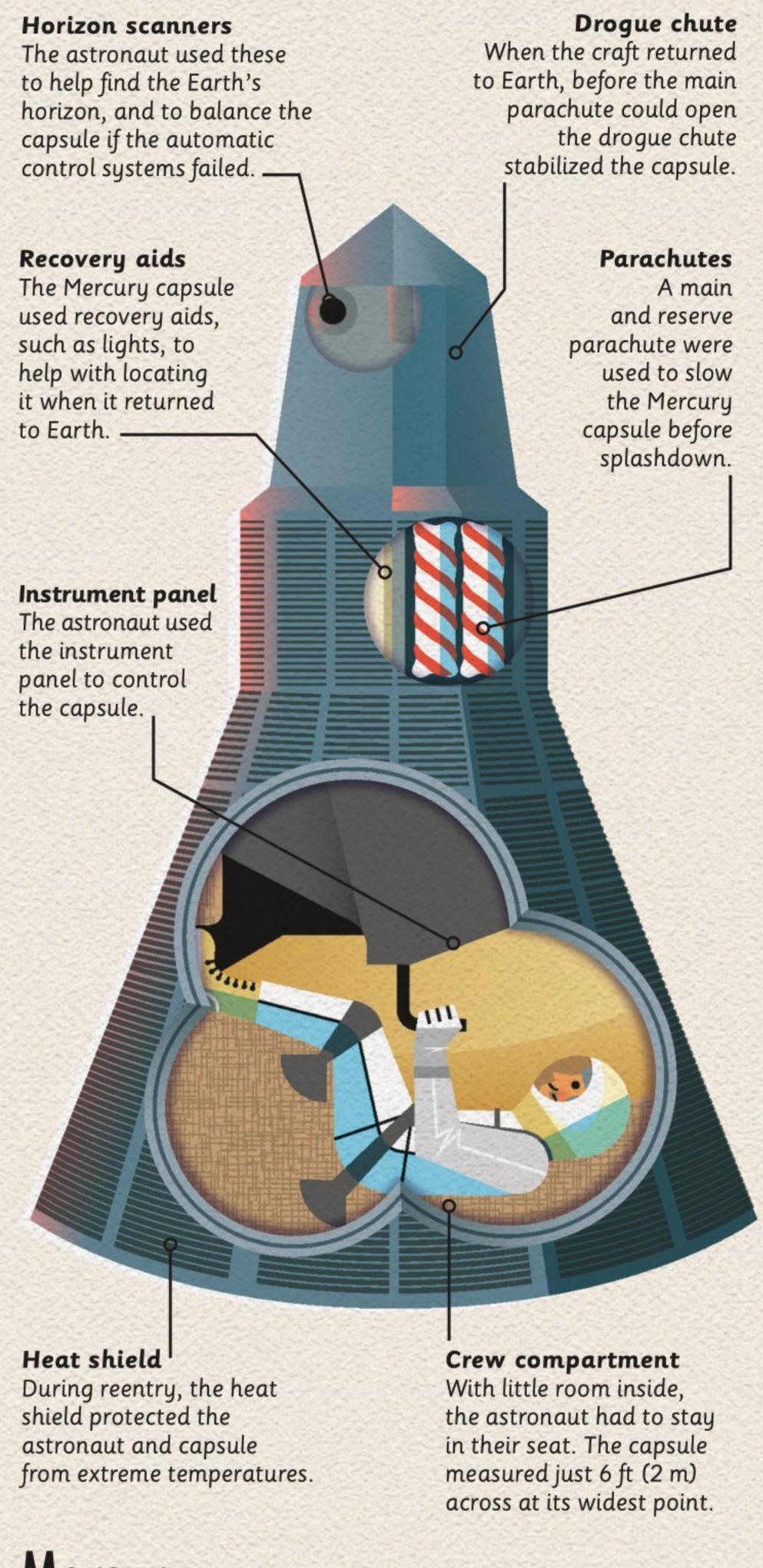
Vostok

The Soviet Union used the Vostok spacecraft to send their first cosmonauts into space. It was first used in 1961 for Yuri Gagarin's mission.

Vostok return mission

As if going to space was not daring enough, the first cosmonauts had to eject from their spacecraft as they returned to Earth and parachute down to the ground. This was because Vostok's landing was so violent, it could have injured the cosmonaut.





Mercury

NASA's Mercury space capsule was designed to splash down in the ocean after returning to Earth. The capsule was used for six crewed space missions, the first of which was in 1961. The longest mission was with Gordon Cooper, who spent more than 34 hours cramped inside and orbited the Earth 22 times!

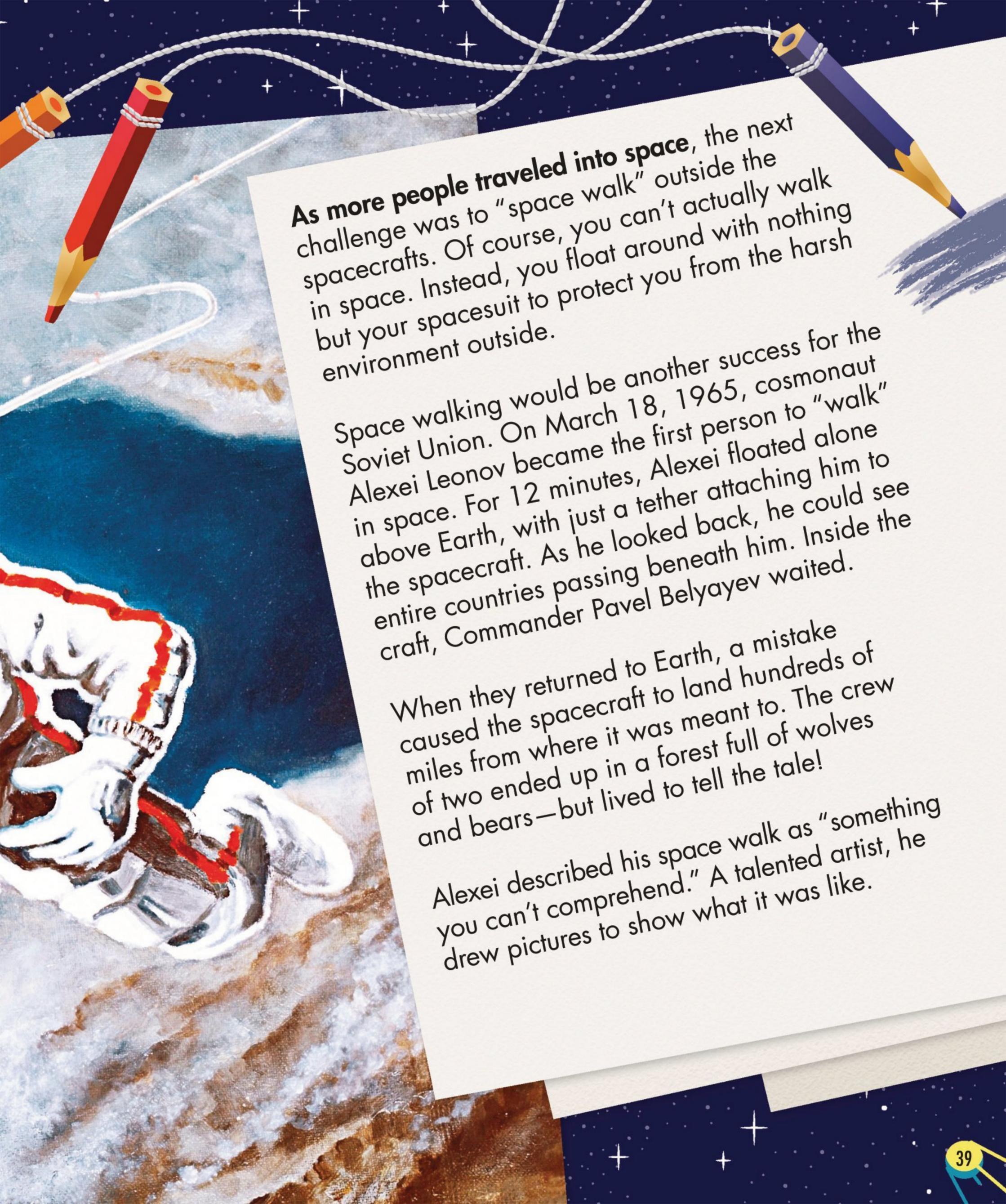
Walking in space

Spacesuit problem



During Alexei Leonov's space walk, his spacesuit overinflated, making him too big to get back inside the airlock. In order to fit, Alexei decided to release some of the oxygen from inside the suit by opening a valve. His quick thinking prevented a disaster!

This self-portrait shows
Alexei in his spacesuit with
the tether that was used to
stop him from floating away.



Project Gemini



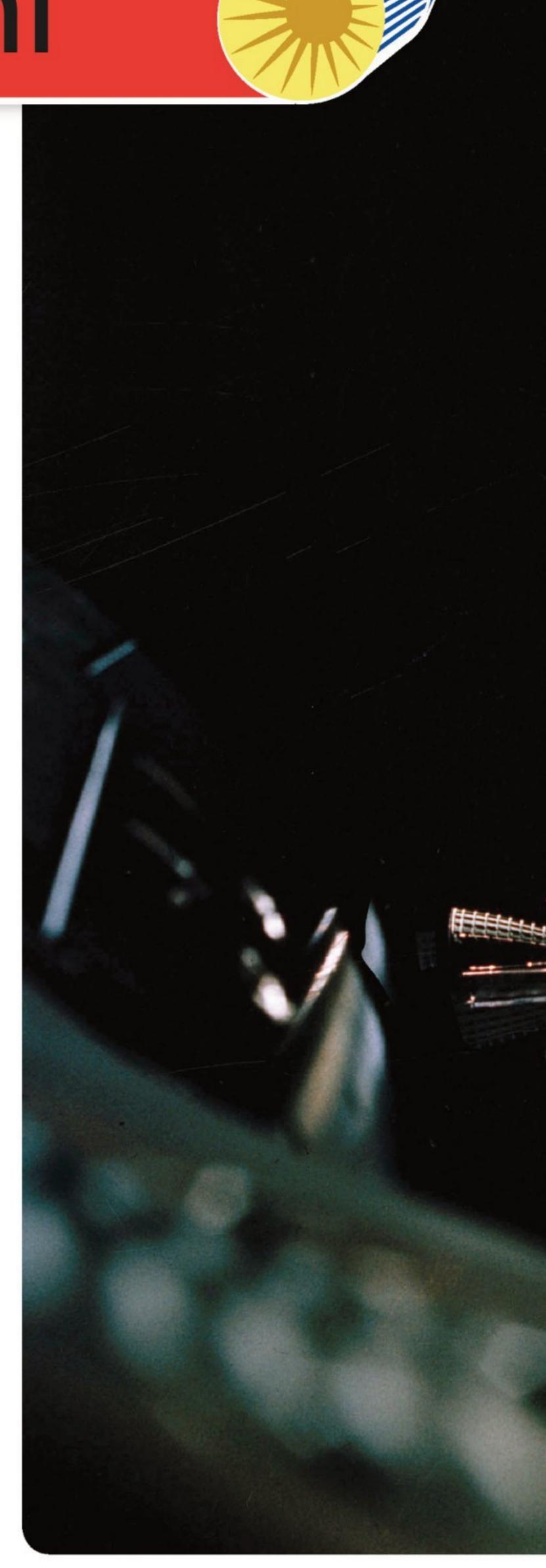
To get to the moon, NASA needed to learn lots of new skills, so it created Project Gemini. Gemini would send two astronauts into space at a time. There, they would learn to walk in space, dock with other spacecraft, and spend more time in space than ever before.

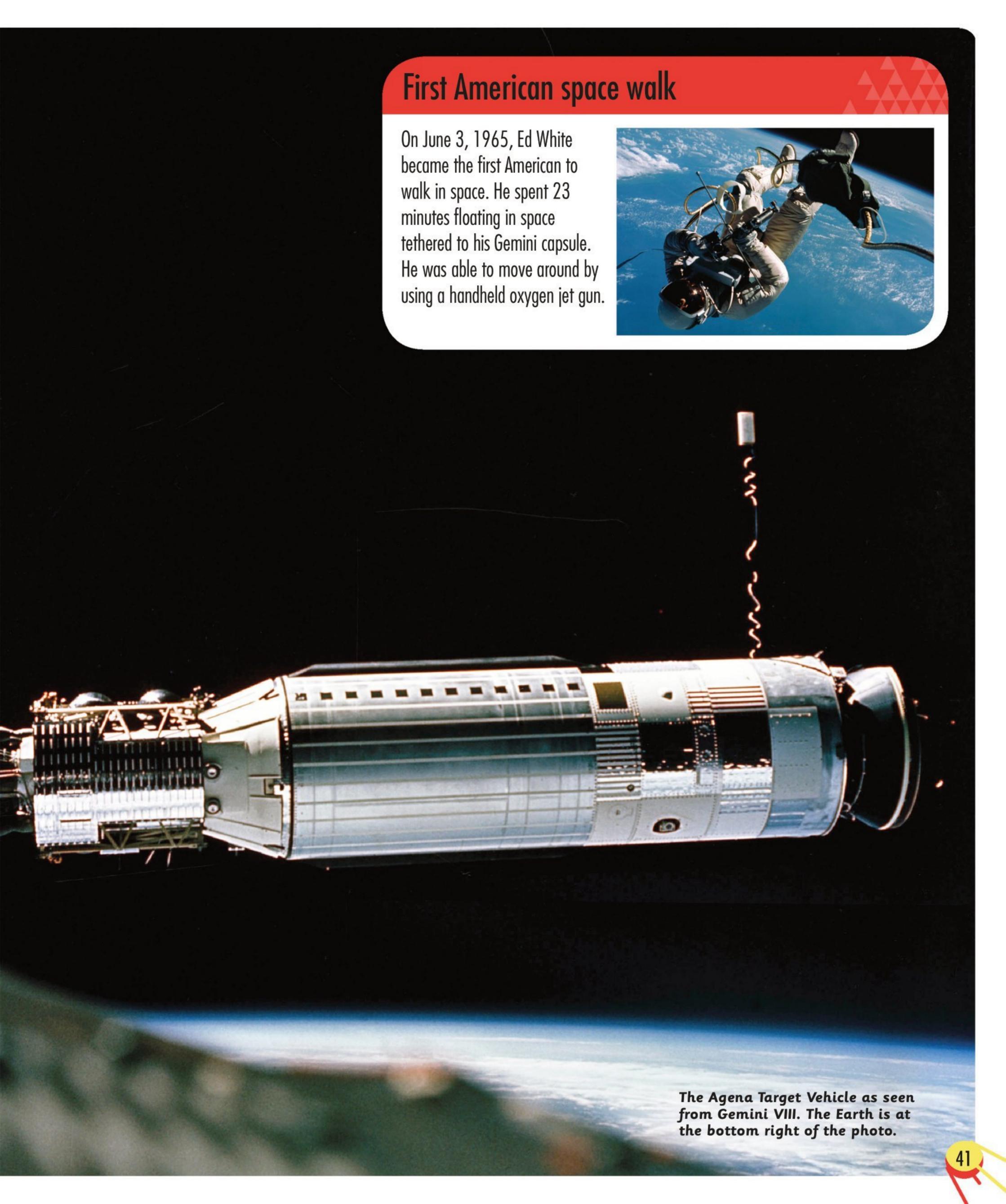
In March 1966, Gemini VIII, piloted by Neil Armstrong and Dave Scott, conducted the first ever docking of two spacecraft in orbit. However, after successfully docking with the uncrewed Agena Target Vehicle, their spacecraft began spinning wildly out of control.

The astronauts were in serious danger, but the quick thinking of Neil Armstrong saved the day. Despite spinning so fast his vision was going blurry, Neil managed to get the spacecraft back under control, aborted the mission, and returned them safely to Earth. Neil's amazing skills as a pilot would not go unnoticed.

Gemini VIII crew First-time astronauts Dave Scott (left) and Neil Armstrong (right) pose with a model of the Gemini spacecraft.







Rocket women

During the space race, all of the American astronauts were men, but women wanted to go to space, too. A group of top female but women wanted to go to space, too. A group of top female pilots underwent the same medical testing as the male NASA pilots underwent the same medical testing as the male NASA pilots underwent the same medical testing as the male NASA injected in their ears and were locked in isolation tanks during injected in their ears and were locked in isolation tanks during grueling mental and physical challenges.

Although 13 passed the tests, they couldn't continue with their dream of going to space—astronauts were required to fly jets, and at the time only men could do that. These pioneering and at the time only men could do that. These pioneering women campaigned to let the testing continue, but with no luck. Among them was Irene Leverton, a well-known aviator of the time who had grown up wanting to fly fighter planes.

However, in 1995 astronaut Eileen Collins turned their dream into a reality when she became the first American woman to pilot a spacecraft. These 13 American women may not have been successful with rocket women may not have been successful with their personal ambitions, but they paved the way for future female astronauts.



Jerrie Cobb

Jerrie poses next to the

Mercury spaceship capsule.

She was the first woman

to complete the tests.

Some of the women during testing. Seated is Sarah Gorelick, who could fly before she could drive a car!



Who were they?



Rhea Hurrle



Myrtle Cagle



Jerrie Cobb



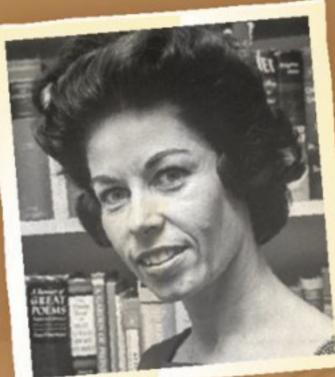
the women to watch

her launch into space

on February 3, 1995.



Janet Dietrich



Marion Dietrich



Wally Funk



Janey Hart



Jean Hixson



Sarah Gorelick



Irene Leverton



Jerri Sloan



Bernice Steadman



Gene Nora Stumbough

An interview with Sarah Ratley (Gorelick)

Q. What was your background in flying?

A. I started flying while in high school and continued working in aviation after college, while being employed full-time in engineering.

Q. Why did you take part in the testing?

A. I was one of the very active women pilots at the time and my name was submitted to Dr. Lovelace.

Q. How difficult was it?

A. The tests were a complete physical and mental examination, but I was determined to pass.

Q. What happened afterward?

A. I continued to be active in aviation and hoped the program would continue.

Q. What are your hopes for the future of the space program?

A. The space program has brought many new inventions and discoveries that help us in our daily lives. As we continue to explore, our quality of life will continue to improve.

Living in a space age

The start of the space race was a very exciting time on Earth. People were no longer just dreaming about space—they imagined a future in space. Space began to influence much of everyday life, from the clothes people wore to the food they ate and the toys children played with.

American astronauts drank Tang in space, as it was powdered and easy to make—you just add water! It became popular on Earth because people wanted to drink the same thing as astronauts.

A futuristic makeover Technology was given to technology around the home. For example, rectangular TVs began to be replaced with smooth, oval-shaped ones.

Suddenly every child

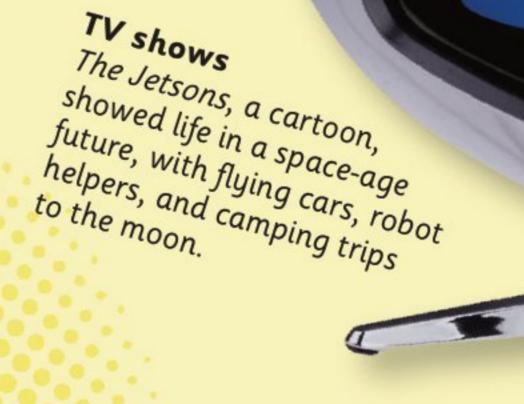
like this one!

Toy rocket

wanted a toy rocket

Furniture

This chair was made by the Danish designer Verner Panton in 1965. It uses the smooth lines and colors found in furniture designed during the space-age era.



Know All Ye by These Presents that

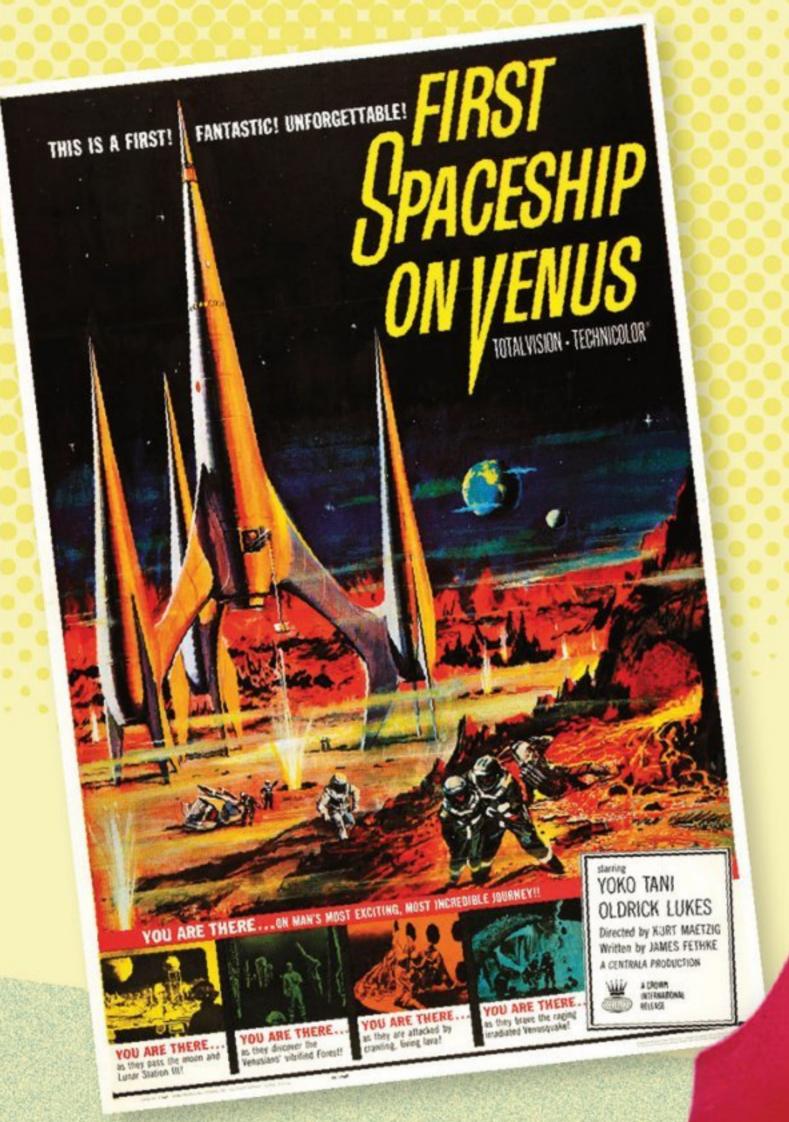
has become a certified member of Pan Am's

Vice President, Sal



MATHEMATI

Ticket to space People were so enthusiastic about space that the airline Pan Am began issuing tickets for trips to the moon.



Sci-fi movies

Movies were inspired by the space race, telling stories of people visiting other planets in the solar system.

Toy robot
Children imagined a future
where robots would help us



World's Fair

In 1964, the World's Fair in New York City showcased a future where space-age technology would improve life for everyone on Earth.

Designers found inspiration in the space race. They created outfits that looked like they might be worn in space, if people ever moved there.

Training for the moon

Reduced-gravity walking

On Earth, gravity keeps you on the ground, but there is a lot less gravity on the moon. NASA helped astronauts to experience what less gravity would feel like by using a reduced-gravity walking simulator.



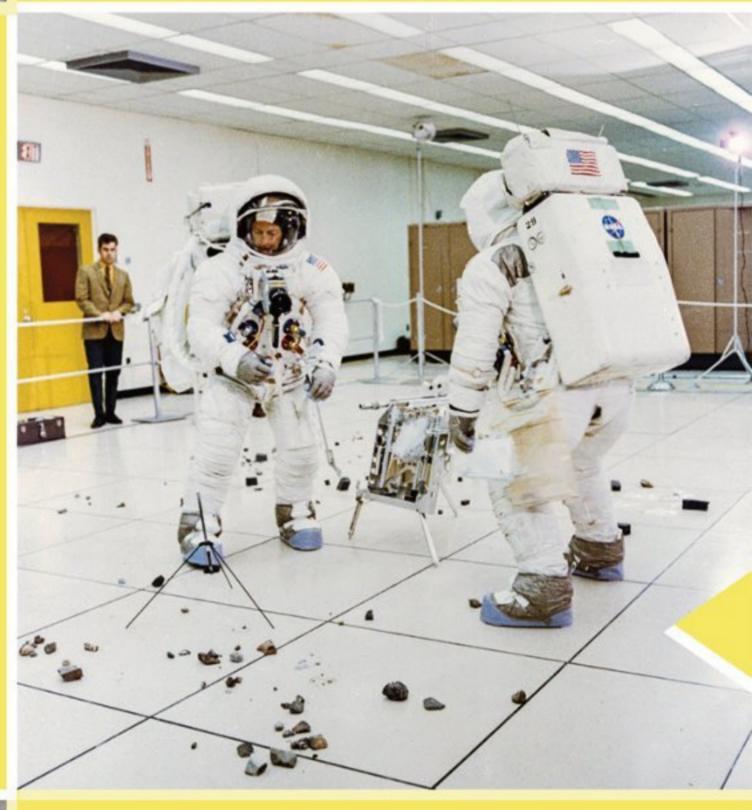
Geology training

Moonwalkers needed to learn about geology. This would help them find the best samples of rocks and soil to bring back to Earth for scientists to study.



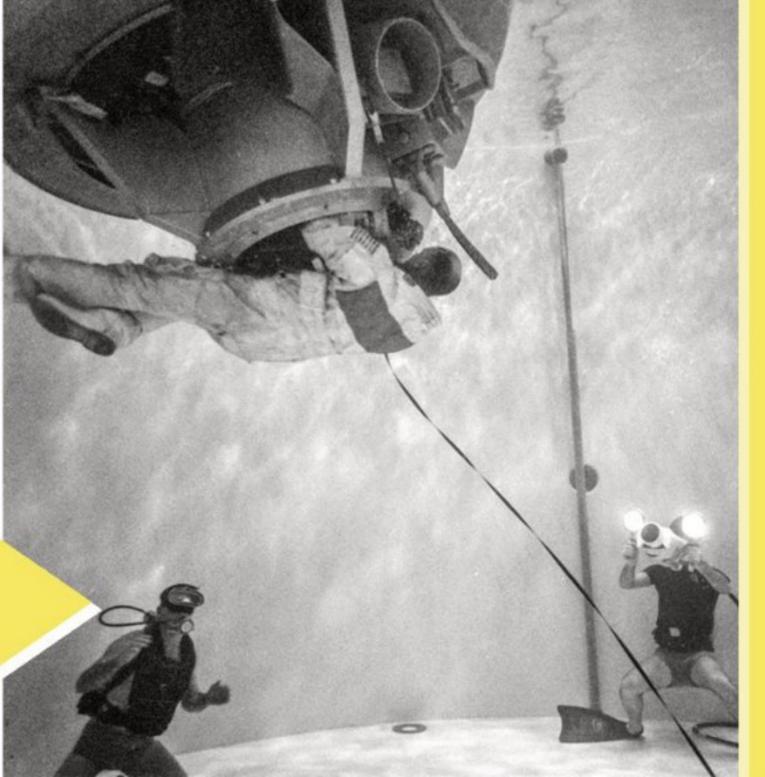
Overcoming tragedy

On January 27, 1967, disaster struck. A fire on the launch pad killed Gus Grissom, Edward White, and Roger Chaffee — the crew of Apollo 1. It took more than 18 months for NASA to successfully send people to space again. The lessons learned from Apollo 1 helped NASA to prevent any American astronauts from dying in space during the Apollo missions.



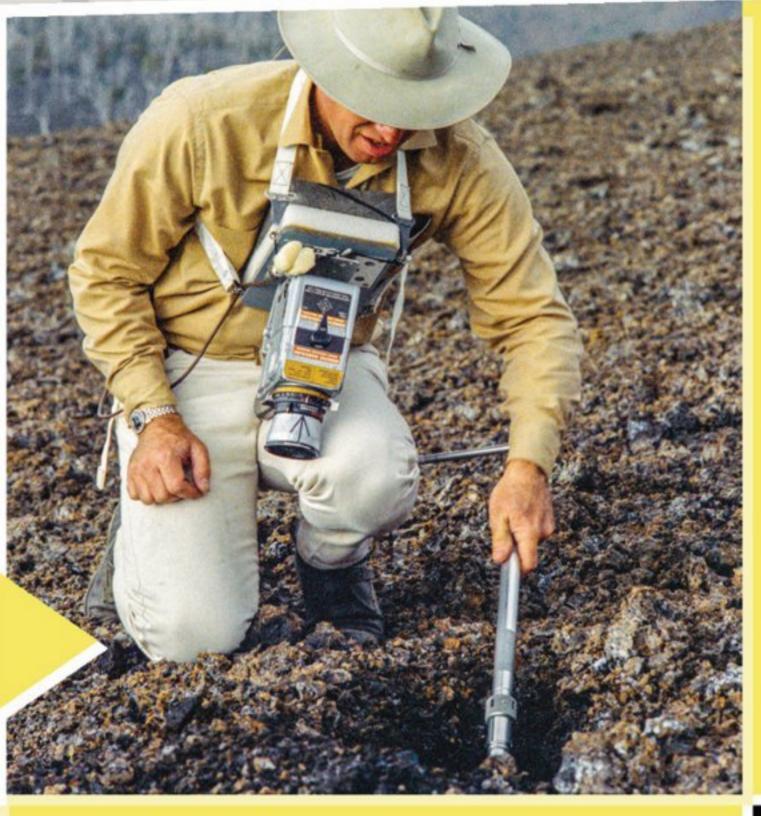
Training underwater

To be an astronaut you have to be able to swim. This is for when your spacecraft lands on water, and also because underwater training is a useful way for astronauts to practice what it would be like to perform a space walk. Here, astronaut Ken Mattingly is seen learning how to exit a spacecraft.



LLRV

The LLRV (Lunar Landing Research Vehicle) looked like a four-legged, flying bed frame. It was incredibly difficult to fly and was used to simulate descending to the surface of the moon.



Tools

Working on the moon, astronauts would need to use lots of different tools. Before going to space, they learned how to use drills, hammers, and scoops while inside their bulky suits.



EVA training

Lunar EVA (Extravehicular Activity) training helped to simulate what it would be like to work on the moon. Astronauts in full gear rehearsed collecting samples and learned how to set up experiments.



Project LOLA

Project LOLA (Lunar Orbit and Landing Approach) was designed to show what it would be like to approach the moon from space. During training, astronauts would move along a track going past a giant, hand-painted model of the surface of the moon.



Water landing

The Apollo Command Module was designed to land on water once it came back from the moon. Astronauts had to learn how to safely climb out of the spacecraft. In this photograph, they are seen practicing in a swimming pool.

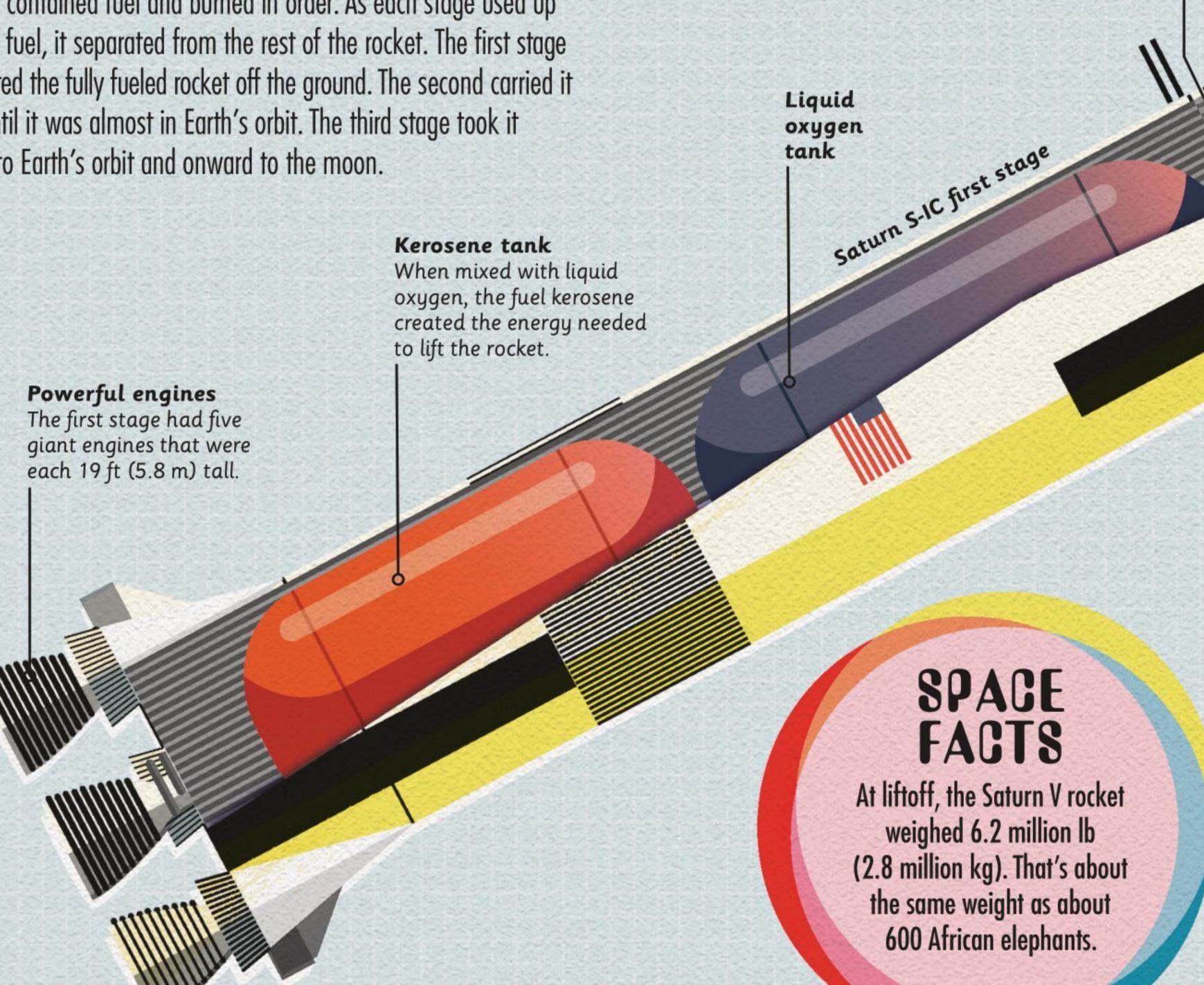


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To get to the moon, you need a gigantic rocket. The Americans built the Saturn V—a type of rocket known as a heavy lift launch vehicle. It was the most powerful rocket that had ever flown, capable of taking astronauts not only into Earth's orbit but also to the moon.

Saturn V

The rocket was made up of three parts, or stages. The stages all contained fuel and burned in order. As each stage used up its fuel, it separated from the rest of the rocket. The first stage lifted the fully fueled rocket off the ground. The second carried it until it was almost in Earth's orbit. The third stage took it into Earth's orbit and onward to the moon.



Super size

The huge Saturn V

rocket was 363 ft

(111 m) tall. That's

more than the height of

the Statue of Liberty and

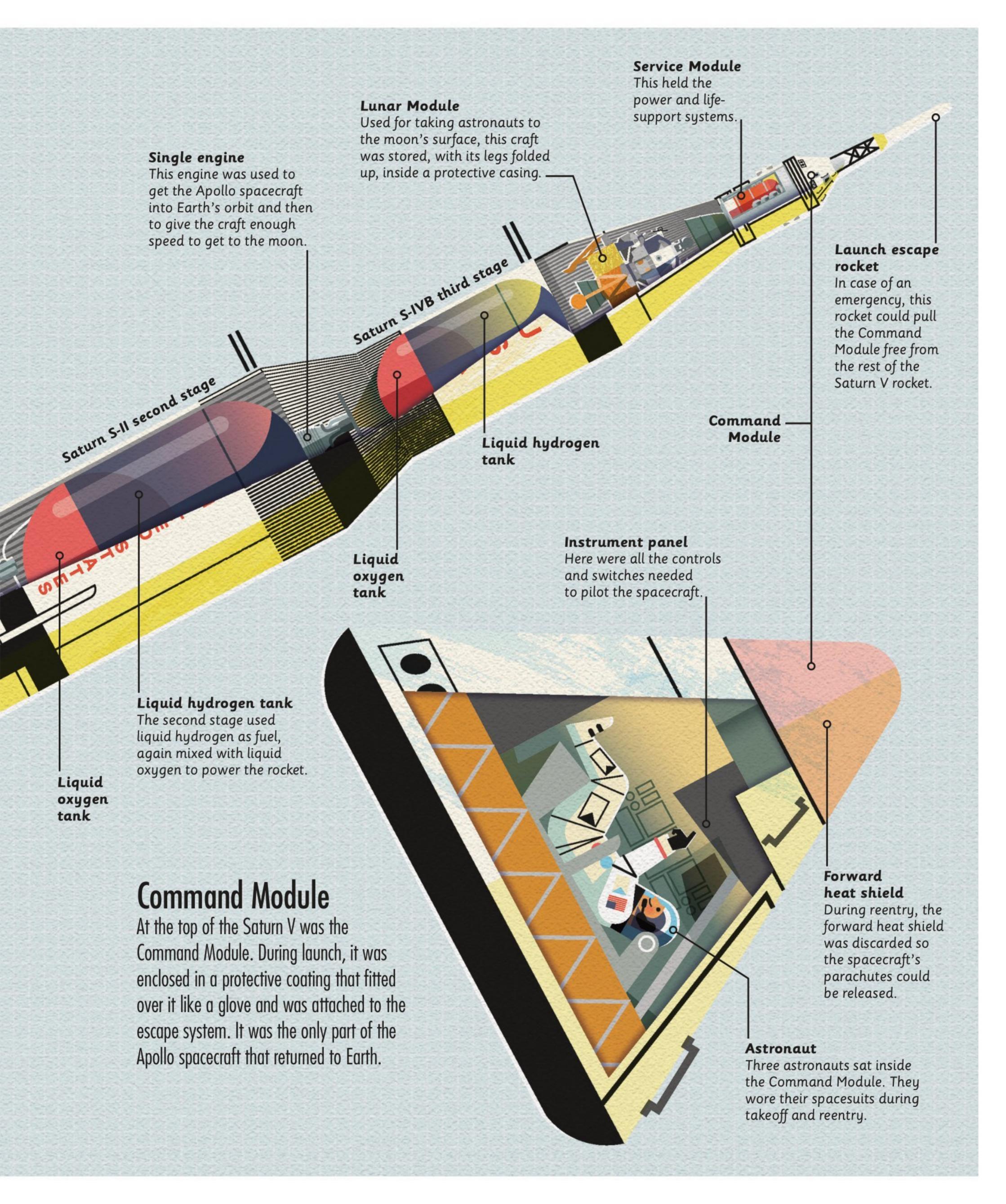
Statue of

Liberty

the base it stands on.

Saturn V

Five engines

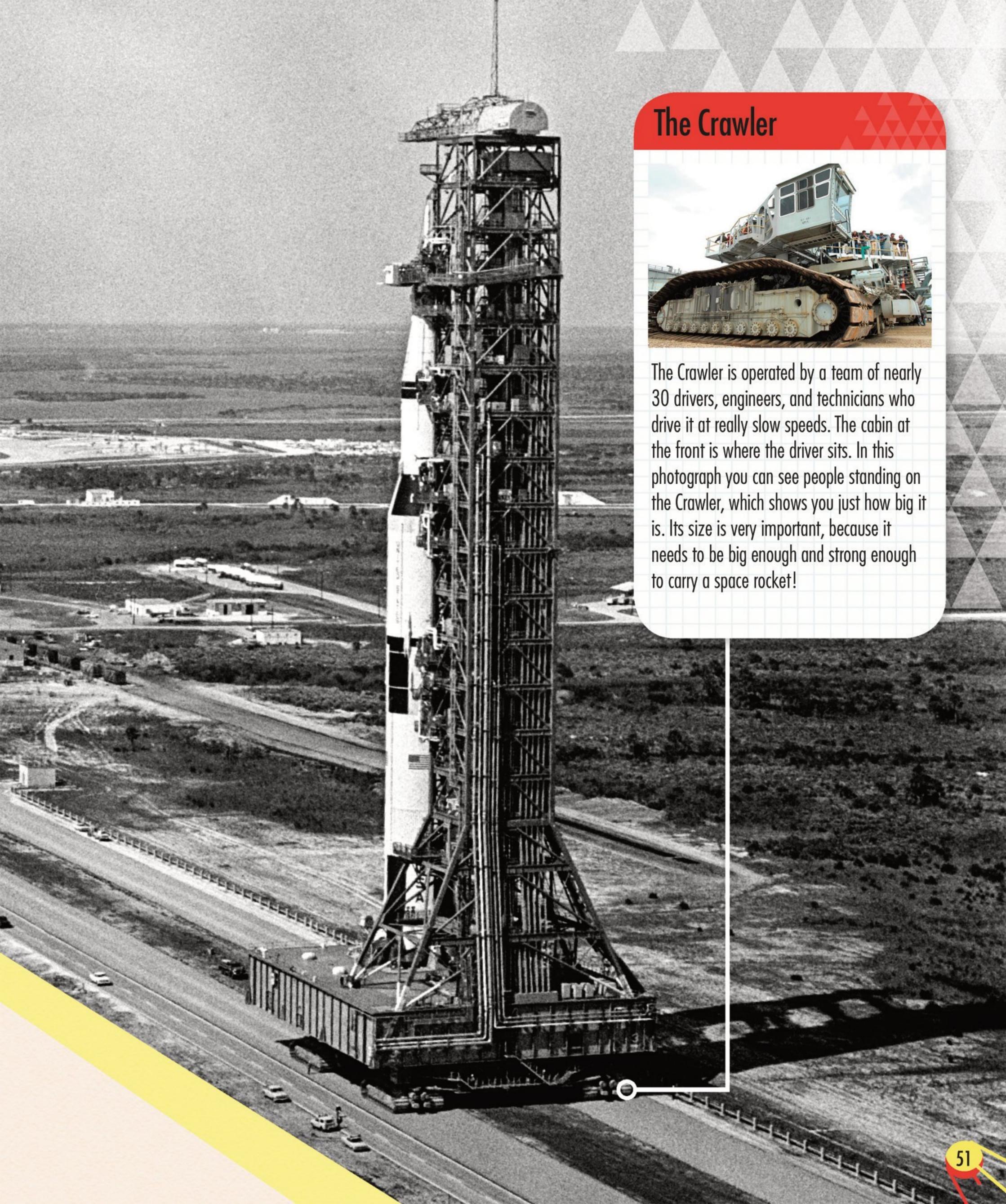


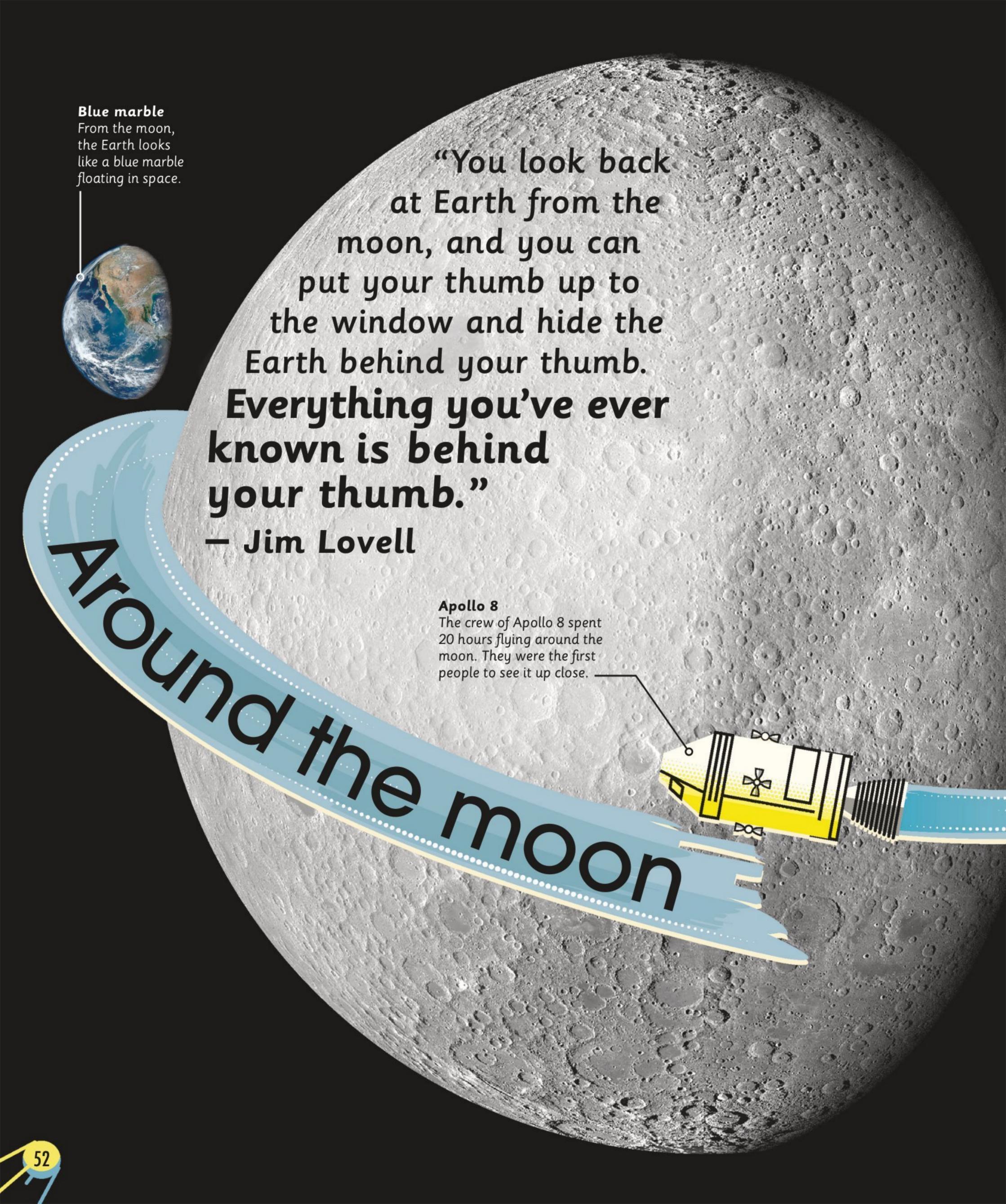
Slo-mo giants

The Crawler is a vehicle with an important job at NASA. It safely transports space rockets from the Vehicle Assembly Building (VAB) to the launch pad, and it has a top speed of just 1 mph (1.5 kph) when loaded. This journey is the last time that a rocket is moved before it blasts into space.

NASA has two Crawlers, which were both built to transport the Saturn V mega-rocket. However, they have been used for lots of space missions since Apollo. The name "Crawler" comes from the fact that it crawls very slowly along the road.

As well as being really slow, the Crawlers are also huge. Each Crawler is 113 ft (34 m) wide, and even without a space rocket onboard they weigh nearly 3,000 tons (2,700 metric tons). They are truly slo-mo giants.





In 1968, fearing the Soviet Union would get there first, NASA decided to send three astronauts around the moon and then return them to Earth. The mission was called Apollo 8. Commander Frank Borman, Bill Anders, and Jim Lovell would travel farther into space than ever before, seeing the moon from a height of just 69 miles (111 km).

The mission was extremely risky, and in order to succeed everything had to work perfectly. On December 24, 1968, the three astronauts arrived at the moon. As they orbited around it, they became the first people to see the far side of the moon. Then, as they edged toward the near side, they saw the most awe-inspiring sight in human history—the Earth "rising" over the moon's horizon.

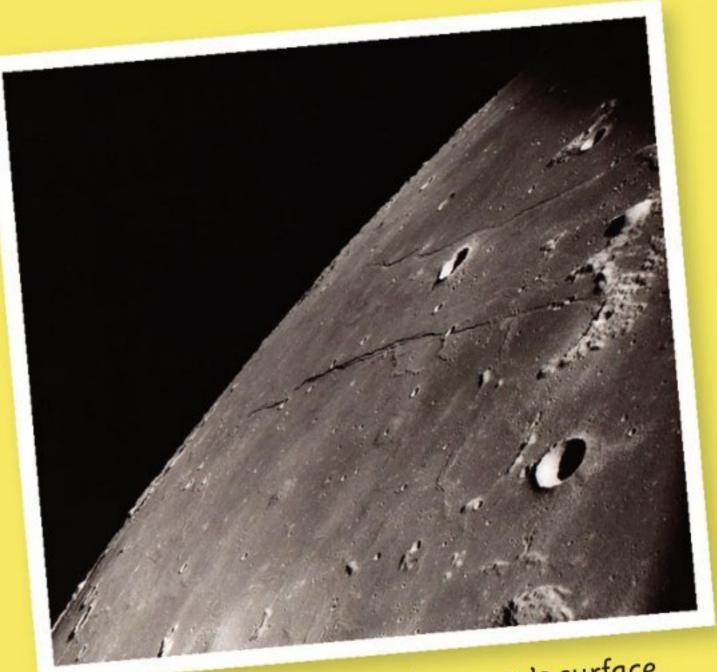
Three days later the crew successfully returned to Earth. Their mission sent shockwaves across the Soviet Union. Up until then, it had been first to do everything in space, but now the Americans were ahead.



The crew of Apollo 8. From left to right: Jim Lovell, Bill Anders, and Frank Borman.



This photograph shows Earth rising above the moon. Taken on December 24, 1968, it's called "Earthrise."



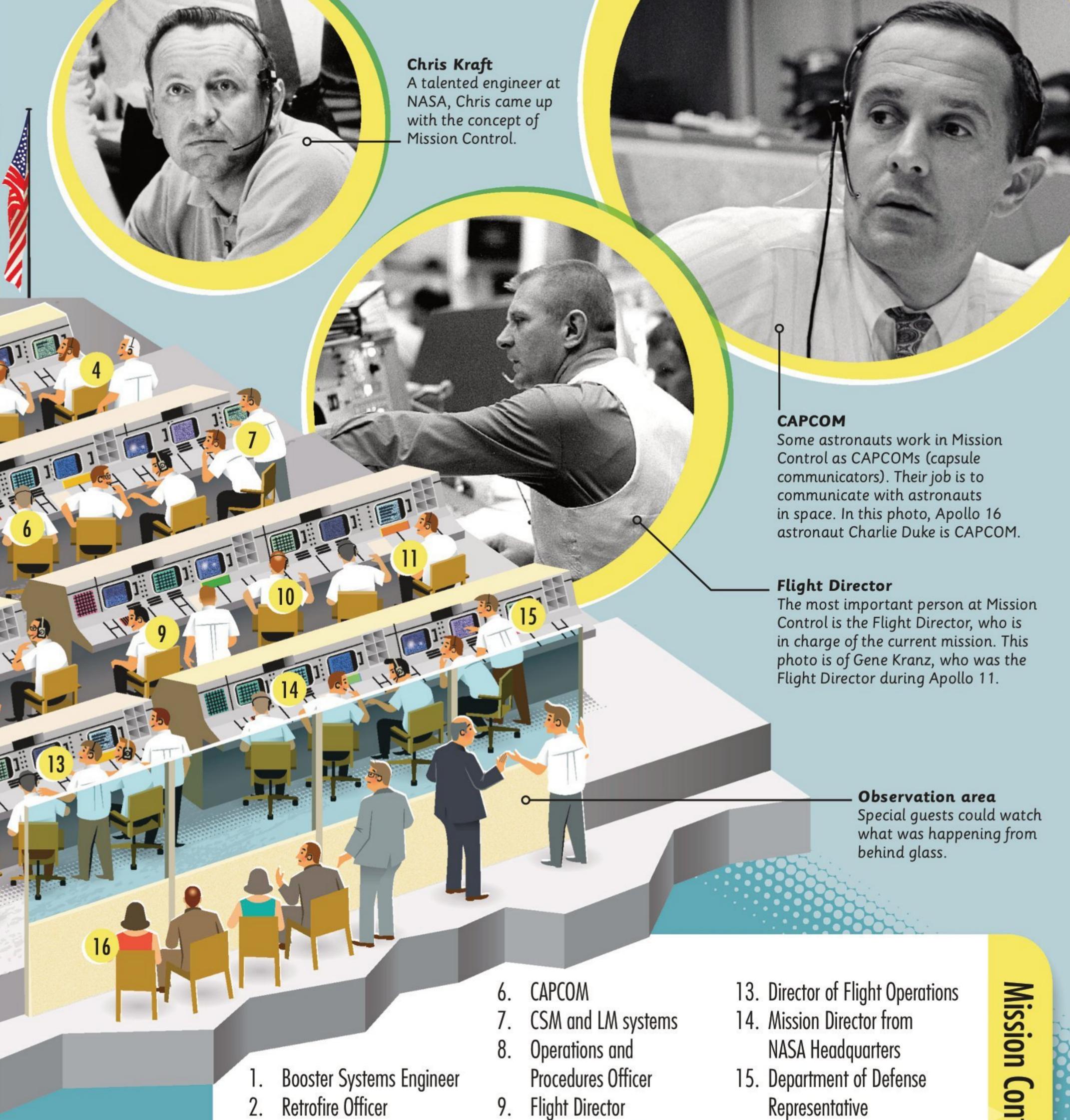
This is a photograph of the moon's surface, taken by the crew of Apollo 8.



During the space race, the Soviet Union had its own version of Mission Control, though details of it were kept secret.



16. Special guests



10. Flight Activities Officer

11. Network Controller

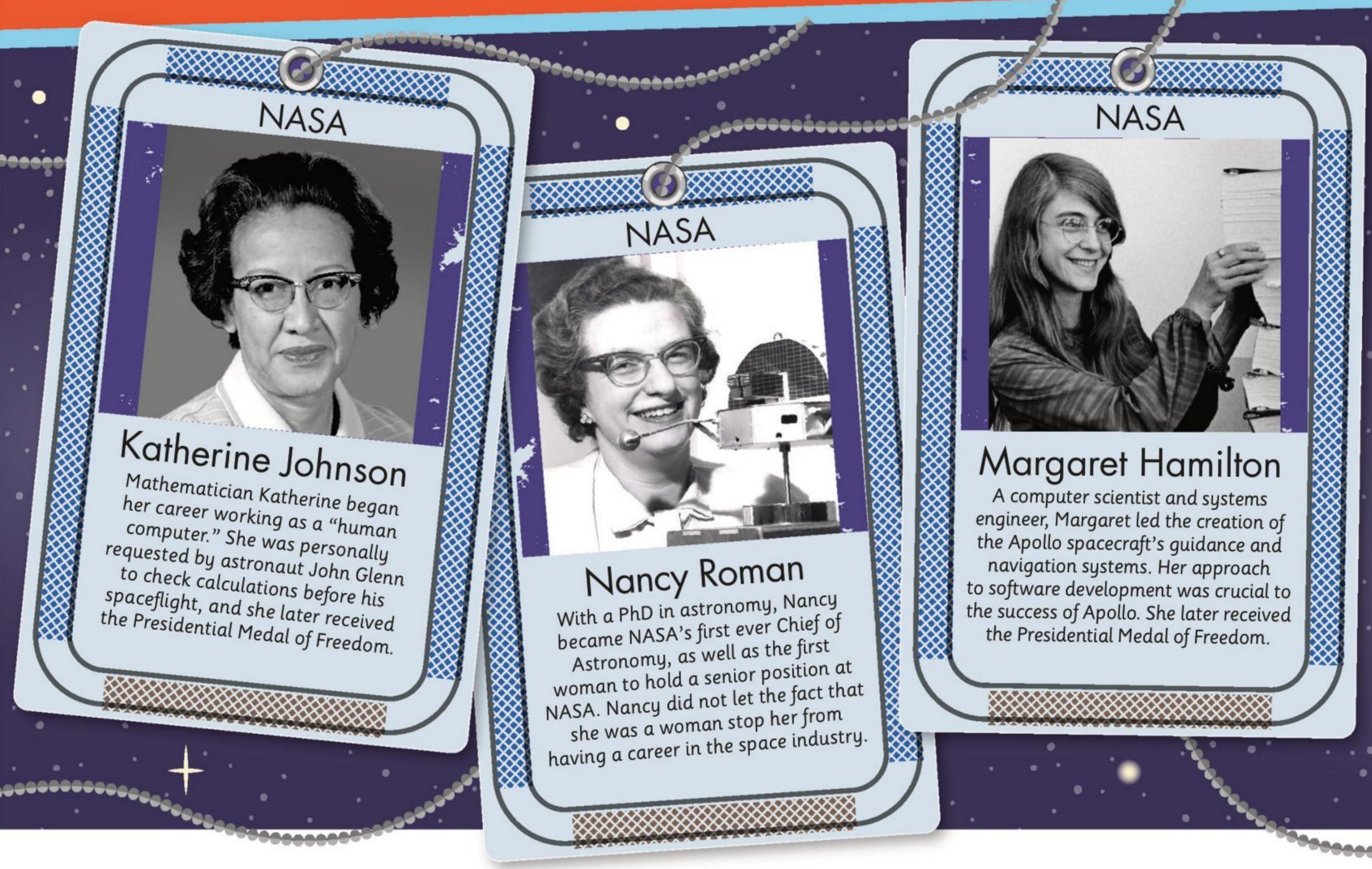
12. Public Affairs Officer

Flight Dynamics Officer

Guidance Officer

5. Flight Surgeon

Traiblazers

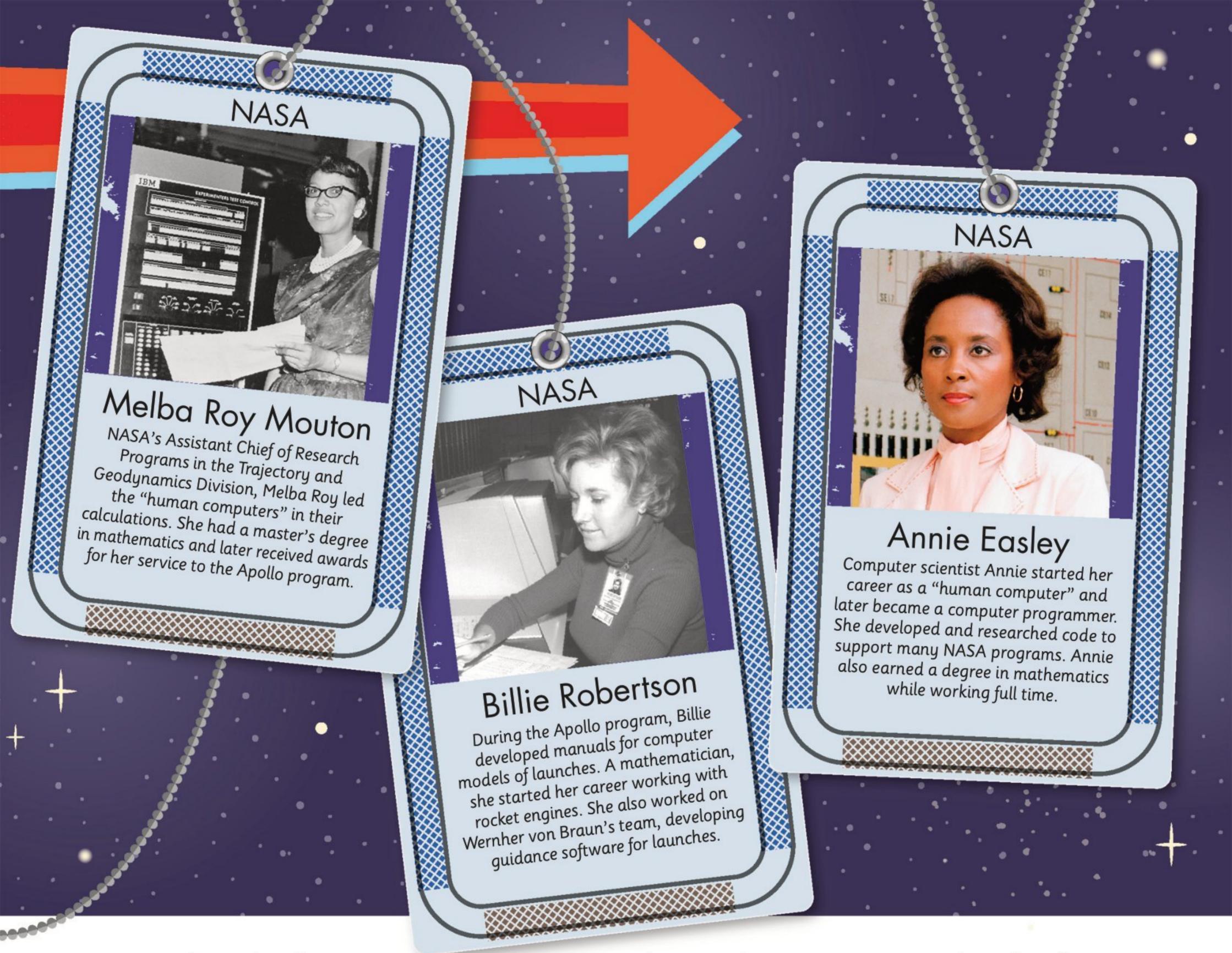


American women weren't allowed to be astronauts, but that didn't stop them from playing important roles during the space race.

In an era when women were expected to get married and stay at home, women at NASA were instead mathematicians, scientists, and engineers. Some faced

additional unfair treatment in society because of the color of their skin, but they were recognized by NASA for their abilities.

Some women worked as "human computers." They worked on math problems and did complicated calculations by hand to understand how a spacecraft would behave during a mission. Today, computers



are used to do this work. Others helped to develop computer codes, which contributed to computer programs that we use in the world today.

These trailblazers worked hard to follow their passion for the space industry, turning ideas about space into reality. Their contributions were not only key to the US's success

during the space race, but for future missions, too.

These women didn't set out to become role models, but their determination to help expand our knowledge of space, while facing the prejudice of the time, made them so. Although they were not as well known as the astronauts, this group, and many other women, were heroes in the space industry.

In order to get to the surface of the moon, astronauts flew a special spacecraft called the Lunar Module (LM). It was extremely lightweight, and was carried into space inside the top of the Saturn V rocket.

The first flight of the Lunar Module was actually around the Earth. It was tested by the crew of Apollo 9 in March 1969. Although it looks upside down in the photo, it really isn't because there is no up or down in space! The crew named the LM "Spider."



View of the Lunar Module from the Command Module

Ladder

The astronauts climbed down a ladder to get to the surface of the moon.

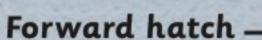
Footpads

Surface contact sensor probes on the footpads told the commander when to switch off the engine after landing..

The radar antenna was used to measure distances when docking with the rest of the Apollo spacecraft.

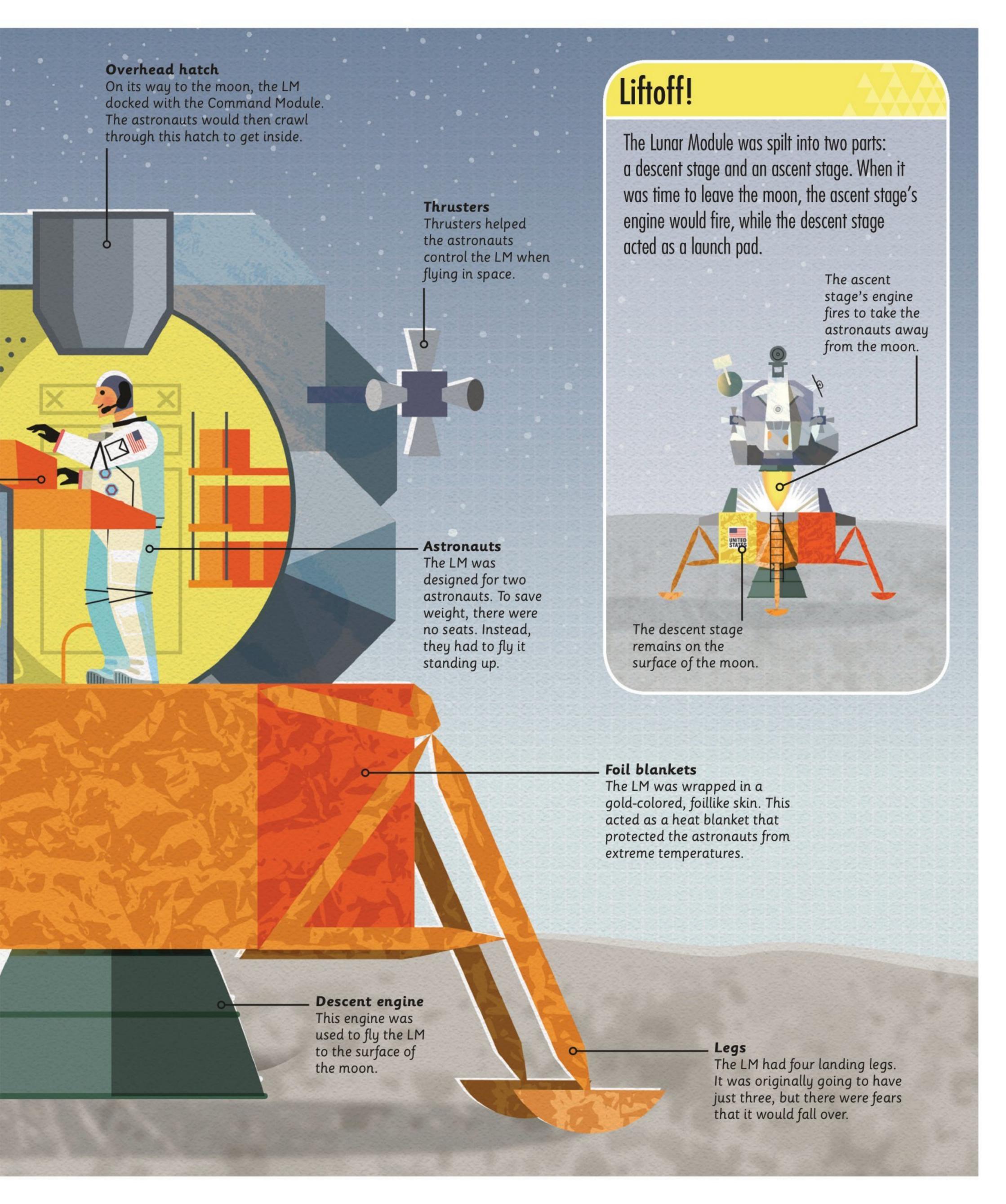
Controls

The control panel was located inside the LM, where there were also small windows to help the astronauts find their landing sites. _



Once safely on the surface of the moon, the two astronauts would crawl through this hatch to exit the LM.





Helmet and visor Astronauts wore a clear, bubble-

Portable Life Support System (PLSS)

pair of sunglasses that could protect

the astronaut's eyes from the sun.

the top. The visor acted like a giant

shaped helmet with a visor over

The PLSS—also known as "the backpack"—contained everything that astronauts needed to stay alive, including oxygen to breathe. It was also a power source for their communications system.

On the moon there is no air to breathe and no shelter from the extreme temperatures and the sun's harmful rays.

Astronauts need to wear a spacesuit to protect themselves and to be able to walk

around safely on the moon's surface.

Apollo spacesuit

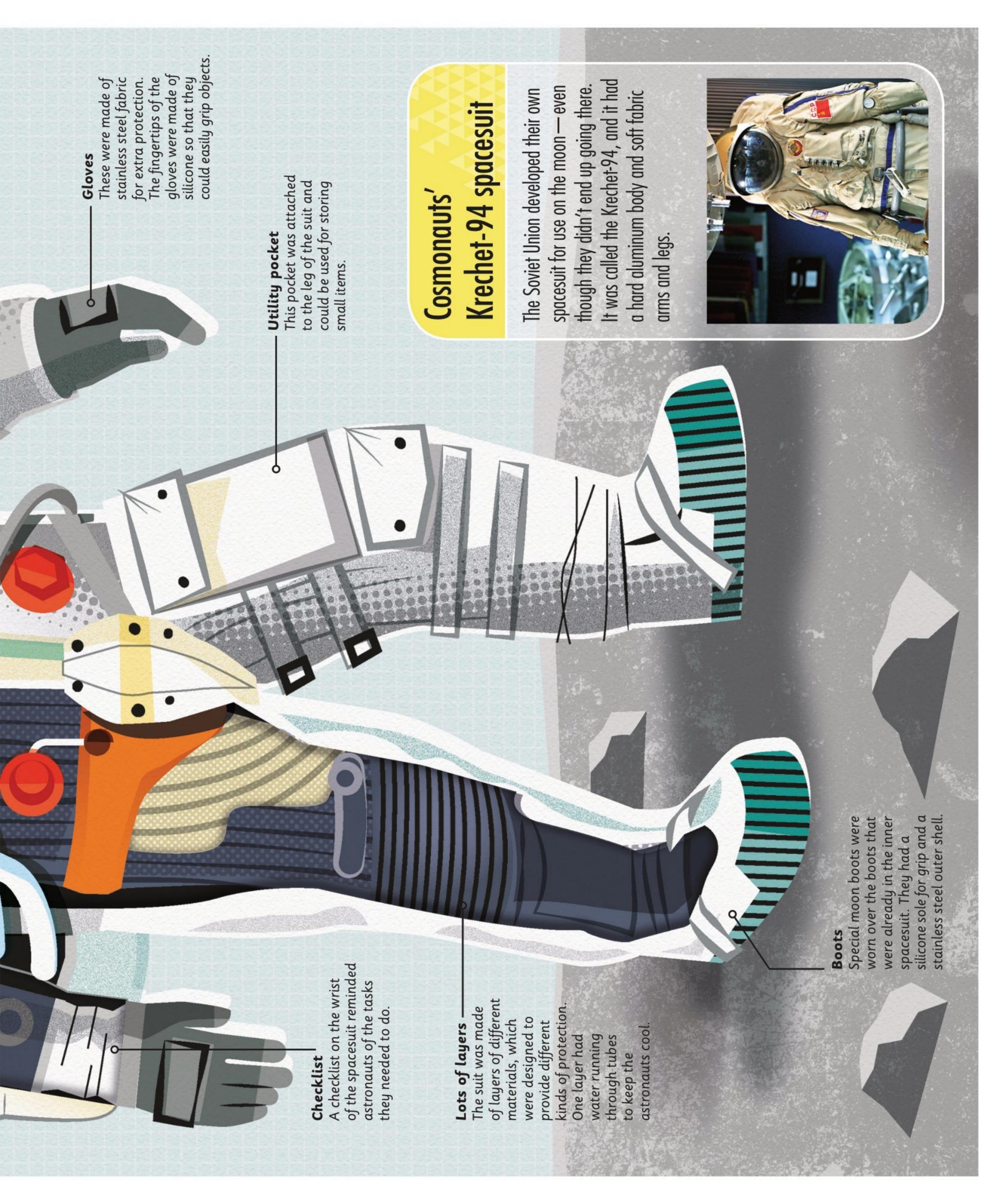
The Apollo spacesuit was worn over other layers of protective clothing. It was designed to be worn not just on the moon, but also during the launch to space and reentry to Earth. The Portable Life Support System, protective boots and gloves, and a visor were added to the spacesuit when astronauts walked on the moon.

- Remote Control Unit

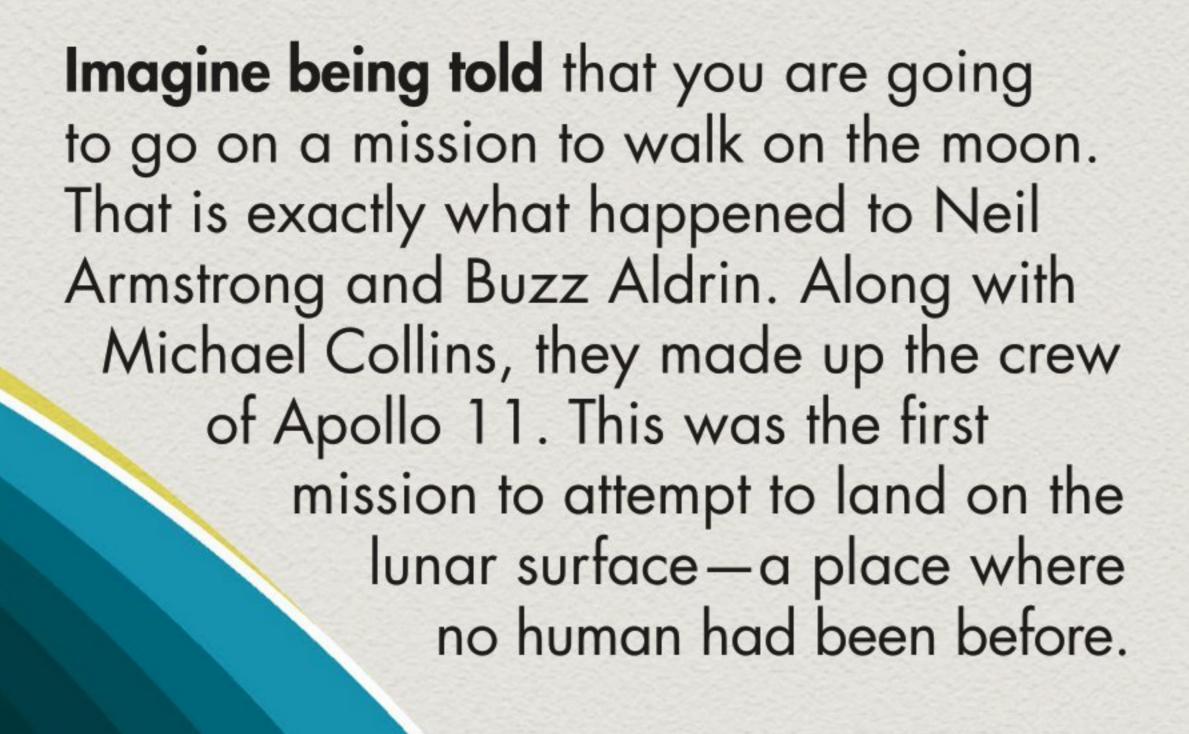
Astronauts used this to communicate. It also provided live updates about the suit's condition and could be used to hold an astronaut's camera.

White outer layer

The outer layer was strong enough to prevent rips and tears, and to keep astronauts protected from small meteorites.









Apollo 11 mission patch
This patch was designed by the crew.
The bald eagle is the national bird of the US, and it is holding an olive branch to represent peace.

By now, NASA had
mastered all of the skills
needed for the mission. They had
even flown the Lunar Module to within
9 miles (15 km) of the moon's surface,
during Apollo 10, in preparation for
a landing. The hopes of achieving
President Kennedy's goal and beating
the Soviet Union rested with these
three astronauts.

Buzz Aldrin

Lunar Module Pilot Buzz had an incredibly scientific mind. He was given the nickname "Dr. Rendezvous" because he had worked on developing ways for spacecraft to meet, and to dock, in space.

However, the Apollo 11 mission also had its dangers. There was a chance the astronauts might not make it home, and some scientists even thought there was so much dust on the moon's surface that the Lunar Module would sink. The crew spent hundreds of hours before the mission practicing in simulators and rehearsing every possible situation.

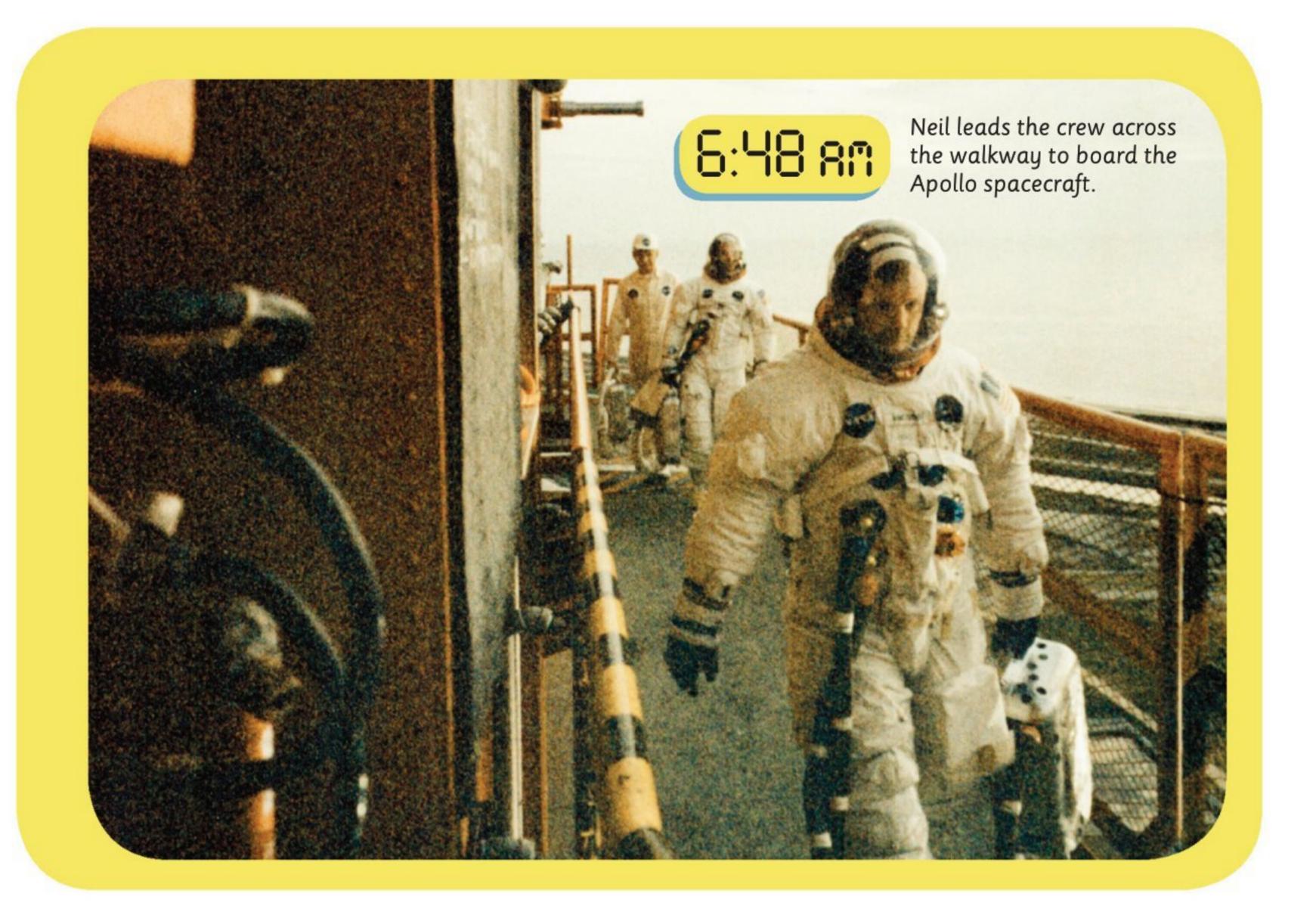
Suiting up

If you're going to be first to the moon, you have to get up early! On July 16, 1969, the crew of Apollo 11 were woken up at 4:15 am. It was the day they were going to launch into space.

After eating breakfast, they had electrodes placed on their bodies. These were designed to provide information about the astronauts' breathing and heart rates during the mission. The crew were then helped into their spacesuits by technicians, which took just over an hour.





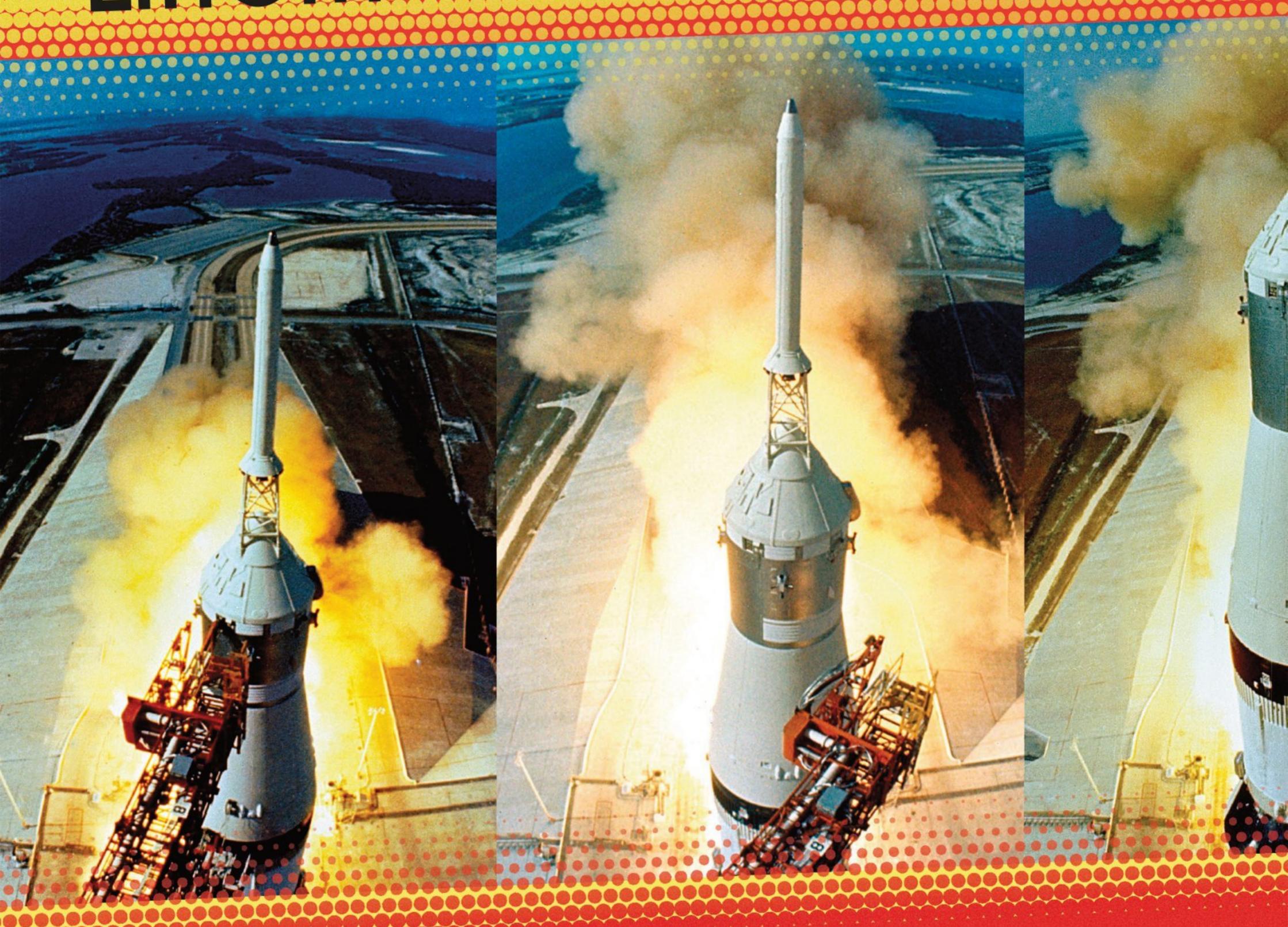




Once snug inside their spacesuits, Neil, Michael, and Buzz had to carry their air supply with them. They waved good-bye to NASA staff and waiting reporters and boarded a van (called the Astrovan), which would take them to the launch pad.

At the launch pad, they rode in an elevator, then crossed a walkway before being helped into their spacecraft by technicians. The spacecraft hatch then shut with a clang—the countdown to the moon had begun.

Liftoff!



More than two hours after the astronauts boarded the Saturn V, the launch teams completed their final checks. The rocket started to come to life and the final countdown began: "10, 9—ignition sequence starts—6, 5, 4, 3, 2, 1, 0. All engines running. Liftoff. We have

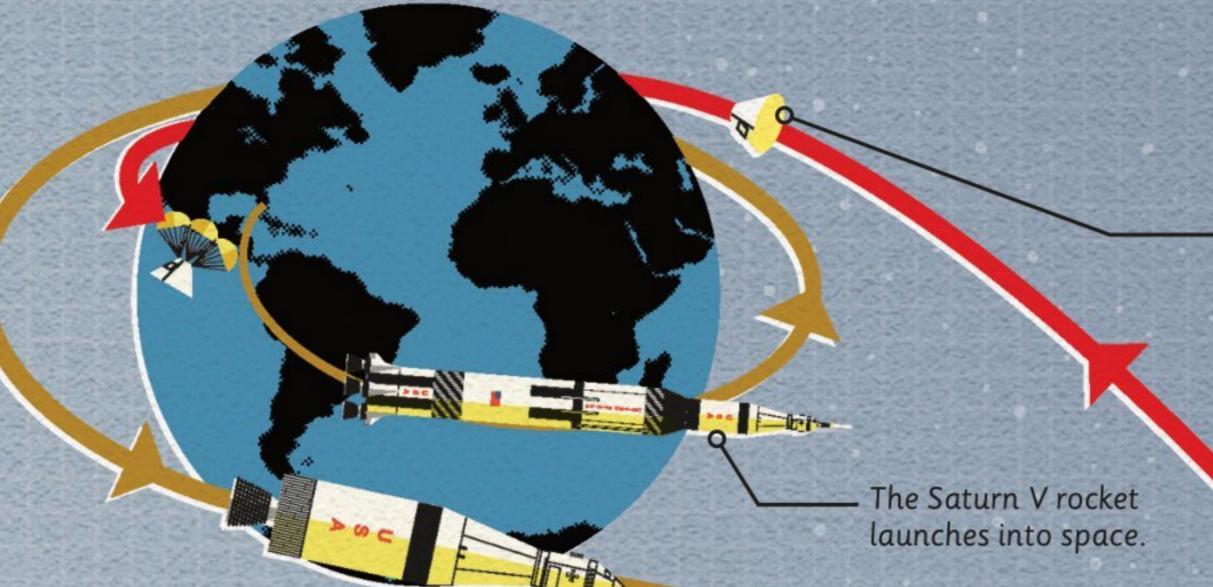
a liftoff." The rocket roared as it began to rise. The noise was so loud that spectators watching from more than 3 miles (5 km) away heard it.

This was the fourth time that the Saturn V rocket had ever flown with people inside it. However, for the

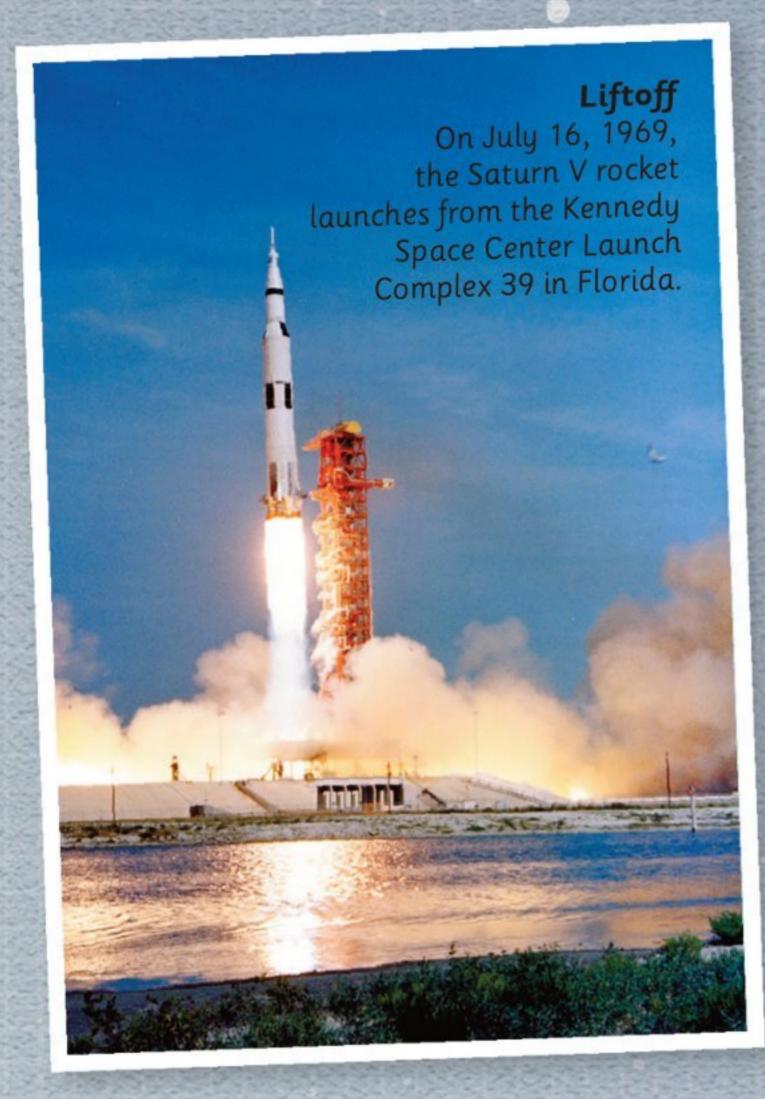


first time in history, and before the Soviet Union, the American Apollo 11 crew would attempt to walk on the surface of another world.

Thousands of people had made the journey to Florida to watch the launch. There were so many photographers taking pictures that the sound of cameras clicking began to drown out the noise of the rocket. The Saturn V rose up through the sky as people looked up in disbelief. In Launch Control, Wernher von Braun watched the rocket he had created as it started its journey to the moon.



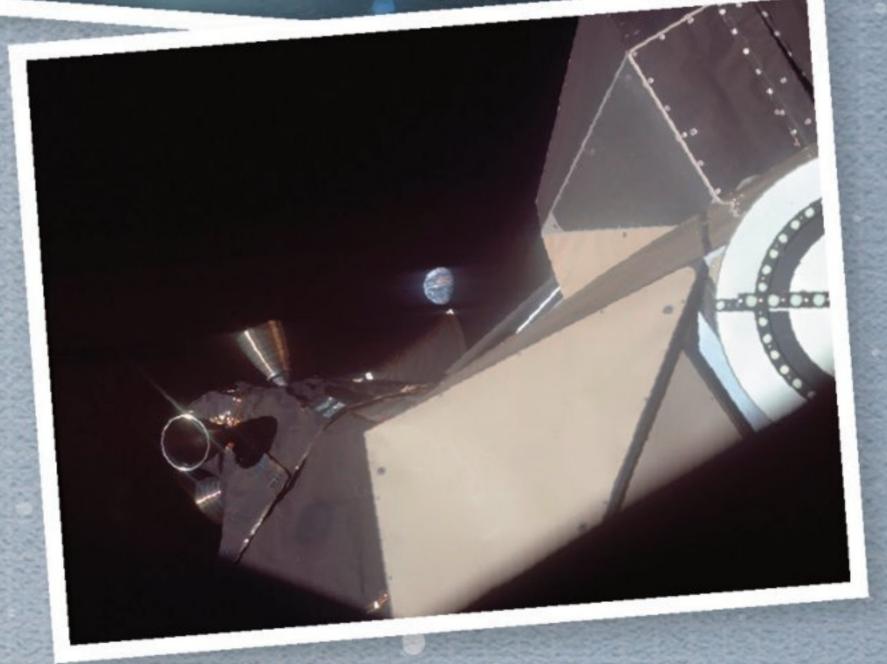
After the Service Module is abandoned, the Command Module, carrying the three astronauts, returns to Earth.



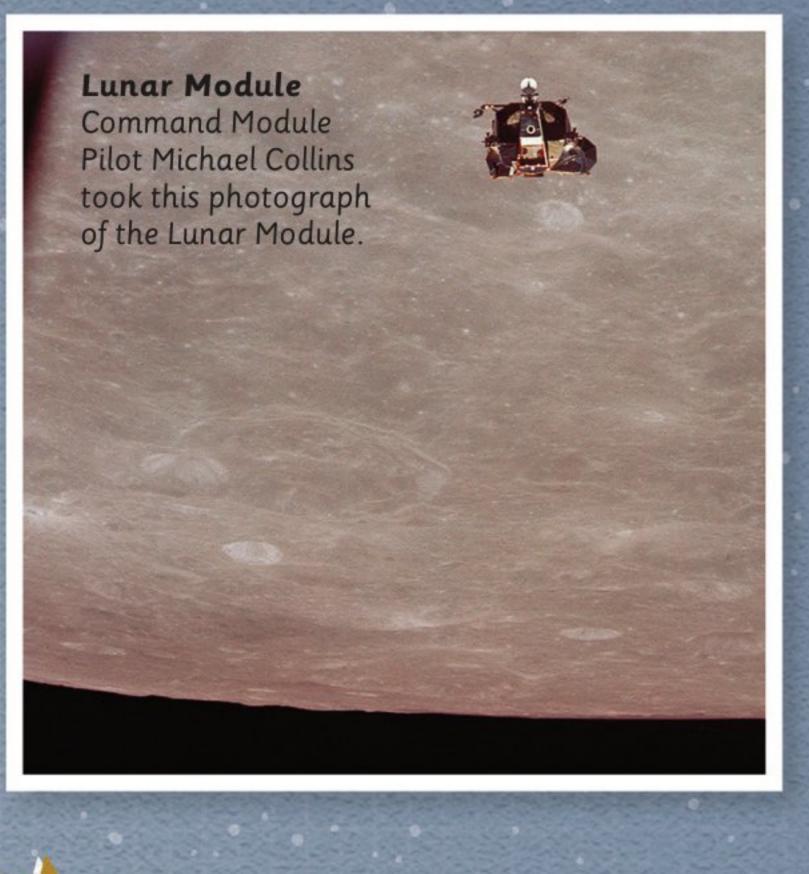
The Command/Service Module, named Columbia, separates from the rocket and the Lunar Module. It then turns around and docks back with the Lunar Module.

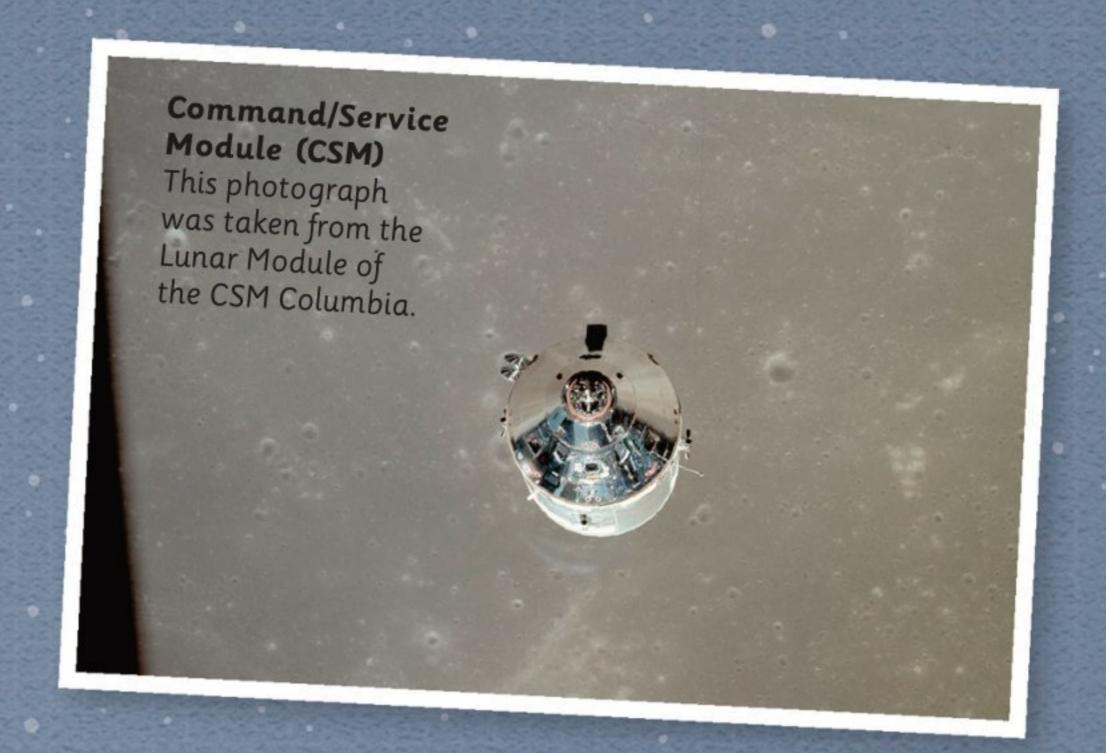
View of Earth from orbit
This photograph of the Earth
was taken as the Apollo
spaceship orbited it before
heading to the moon.

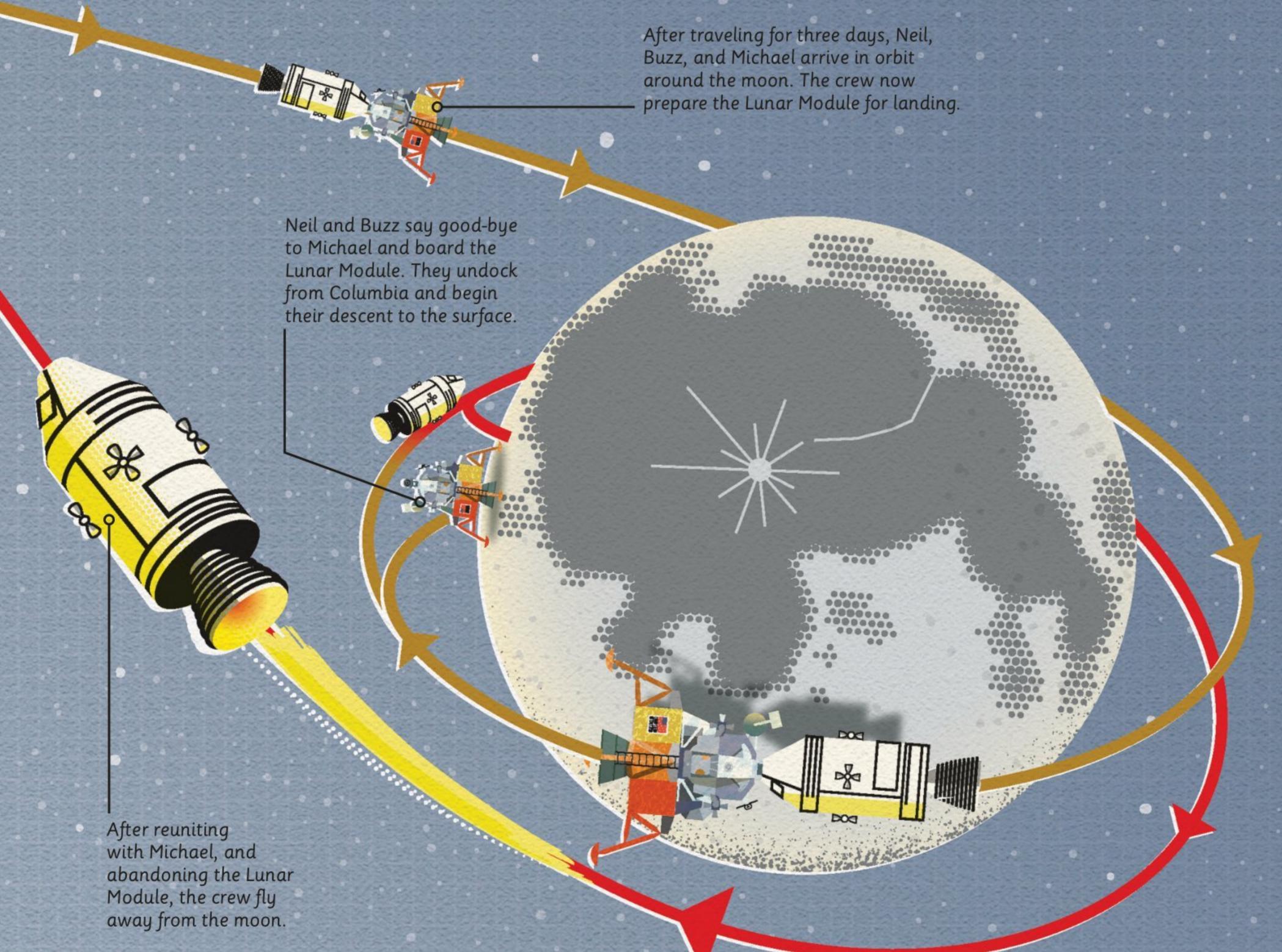
From launch to splashdown, the Apollo 11 mission would last eight days. After leaving Earth's orbit, Neil, Buzz, and Michael were in constant communication with the team at Mission Control. They even appeared on TV to talk about their journey.



Goodbye, Earth
As they continued on their journey, the astronauts looked out of the window to see the Earth becoming smaller and smaller.







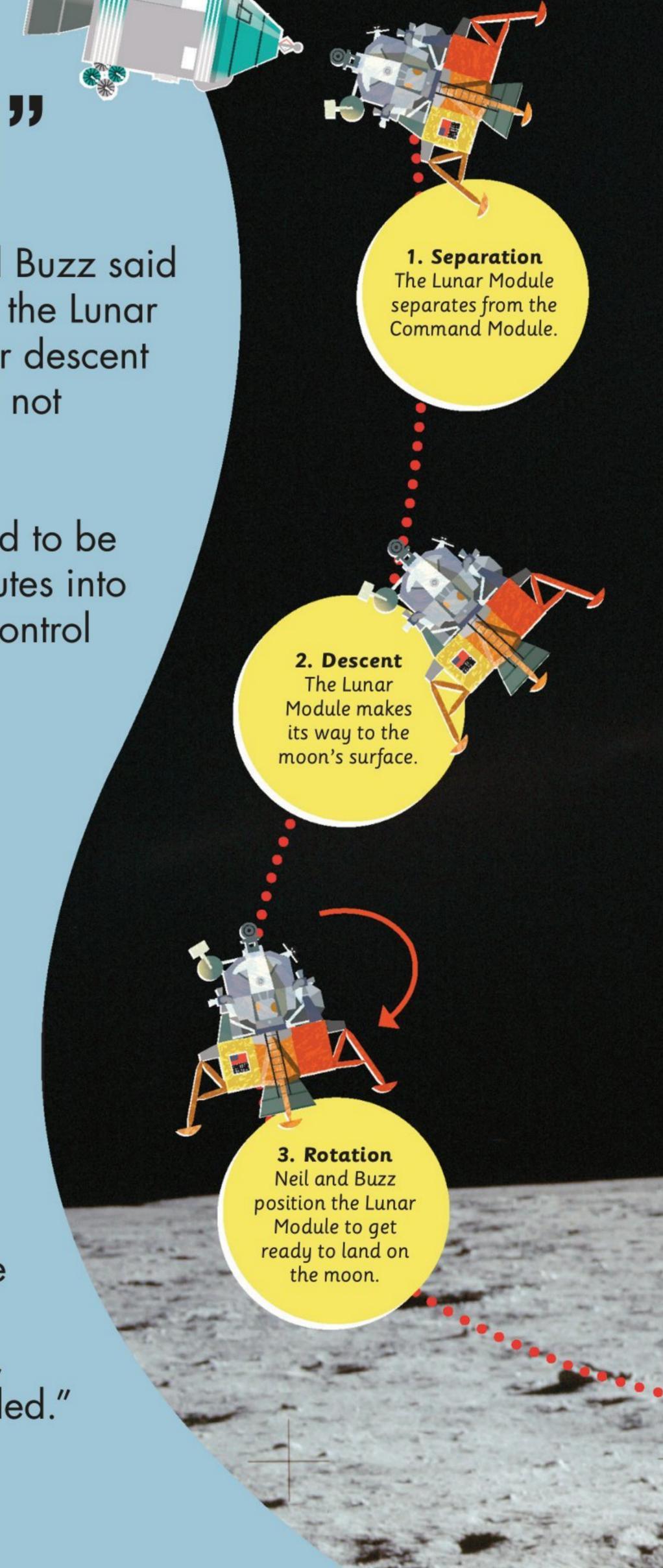
"The Eagle has landed"

Once in orbit around the moon, Neil and Buzz said good-bye to Michael and crawled inside the Lunar Module, called the "Eagle," to begin their descent to the surface. However, the journey was not without danger.

On the way down, the mission nearly had to be aborted after an alarm sounded just minutes into the landing sequence. Back at Mission Control in Houston, the team worked hard and managed to solve the problem.

As they continued toward the surface, Buzz concentrated on the instrument panel, calling out critical information, as Neil steered. But there was another problem—they were heading for a boulder field! Neil began to look for a new place to land.

With less than 30 seconds of fuel remaining, the descent engine began to kick up dust as the Eagle closed in on the surface. Then, touchdown. Neil radioed back to Earth the famous lines: "Houston, Tranquility Base here. The Eagle has landed." The date was July 20, 1969.



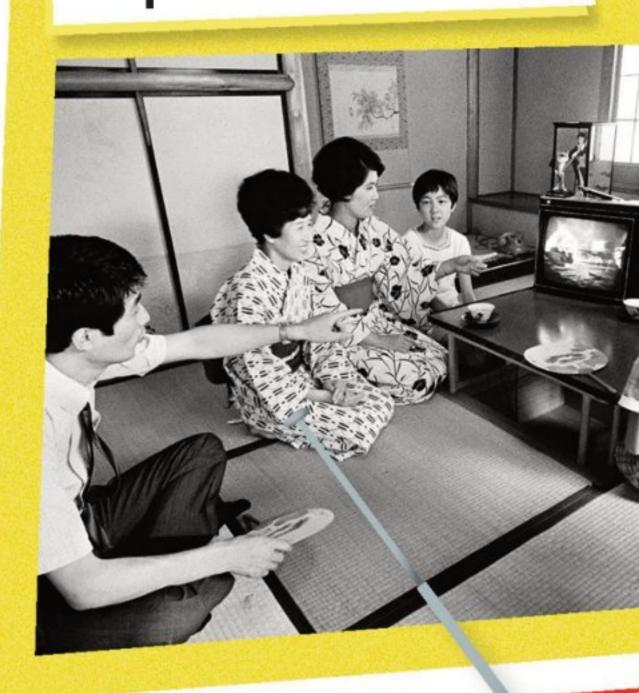


United States

Among those watching in the US were the families of the crew.
Michael Collins's wife, Pat (far left), is seen here with their daughter, Ann, who is wearing a red robe.



Japan



The world watches



UK

In London, crowds gathered in front of a huge TV screen that was put up in Trafalgar Square.





In Tokyo, a family watches on their TV set as Neil and Buzz are seen saluting from the moon.

Pope Paul VI watched the TV coverage as Neil and Buzz landed safely on the moon.

Italy





More than 600 million people were watching as Neil Armstrong climbed down the ladder of the Lunar Module and stepped onto the moon. As he did so, he uttered the words, "It's one small step for man, one giant leap for mankind."

News reporters who were covering the story watched with wonder. Neil Armstrong, a 38-year-old American, had just become the first person to set foot on the surface of the moon. Something that had seemed impossible for so long was actually happening.

Kuwait

Australia

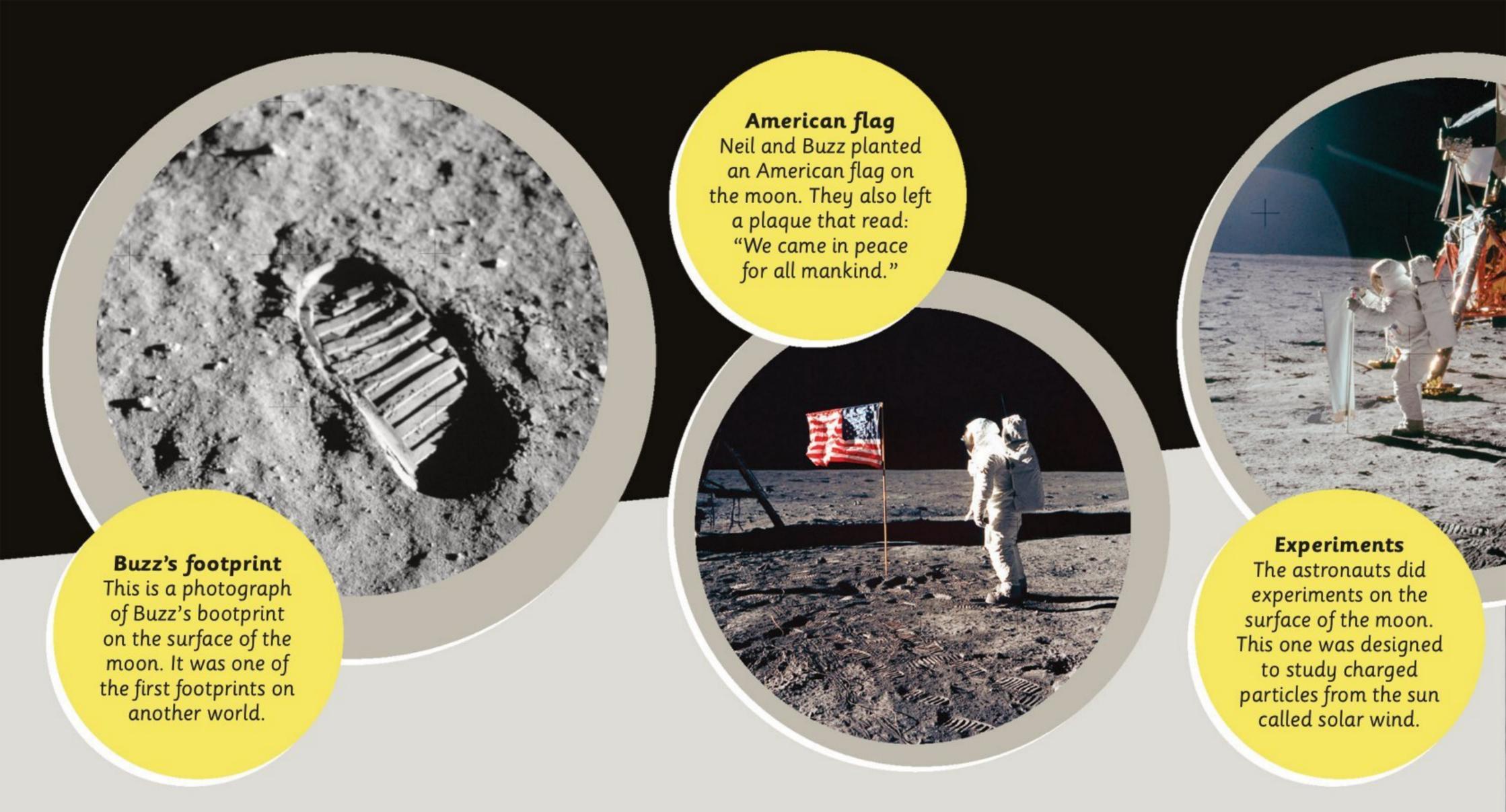
At Mascot Airport, Sydney, people stopped what they were doing and watched Neil take his first steps on the moon.



to watch the footage on TV.

In Kuwait, families

sat down together



On the moon

Shortly after Neil set foot on the moon, Buzz joined him on the surface, describing what he saw as "magnificent desolation." The moon had an empty, gray landscape, no air, and a black sky. Neil and Buzz were the only living things there.

On the moon, there is less gravity than on Earth. This means that the astronauts could bounce around on the surface, even though they were wearing heavy spacesuits. The two astronauts gathered rock samples to bring back for scientists to study.

They also set up experiments. They even spoke to the President of the United States, Richard Nixon, who congratulated them. He told Neil and Buzz that it was "the most historic phone call that had ever been made from the White House."

After 2 hours and 31 minutes, the astronauts' moonwalk was over. Neil and Buzz climbed back up the ladder into the safety of the Lunar Module. They rested and prepared to reunite with Michael in the Command Module to return home.



The Apollo 11 astronauts' journey
home from the moon was not without
danger. In fact, if it wasn't for a felttip pen, Neil and Buzz might never
have left the surface of the moon.
Buzz had to use the pen to push
a switch to start the engine of the
Lunar Module, Eagle, after the
switch had accidentally

been broken off!

to Earth. Just before reentry into Earth's atmosphere, Neil, Buzz, and Michael strapped themselves tightly in their seats.

The return through the atmosphere was like being inside a fireball.

As the Command Module passed through the atmosphere at high speed, the air in front of the module was squashed, which created extreme heat. However, a heat shield protected the module and the astronauts inside.

After rejoining
Michael, they fired the
engine of the Command/Service
Module, Columbia, and began
their voyage back

At about



The Command Module falls to Earth

At about 2 miles (3 km) from the ground, the main parachutes fired open. They helped slow down the Command Module. Then, splashdown! The module landed in the Pacific Ocean.

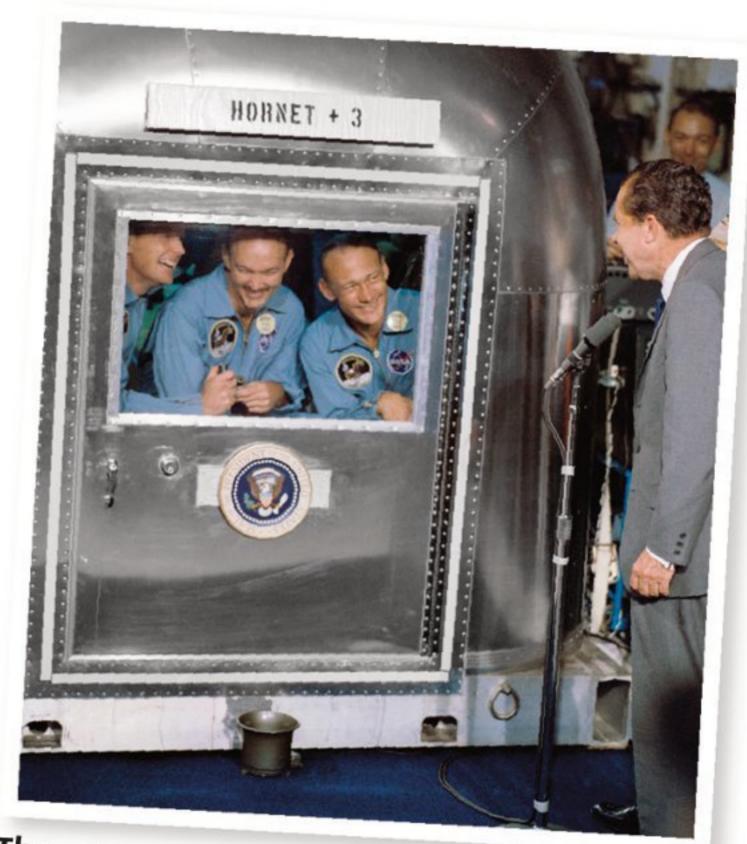
At Mission Control, people celebrated. The Americans had won the race to the moon.

Quarantine

After their return from the moon, Neil, Buzz, and Michael had to spend 21 days in quarantine, or isolation. There had been fears that they may have been carrying deadly lunar germs! It was later confirmed, however, that the moon is lifeless, so there was no need for concern.



Inside the Mobile Quarantine Facility



The astronauts meet President Richard Nixon





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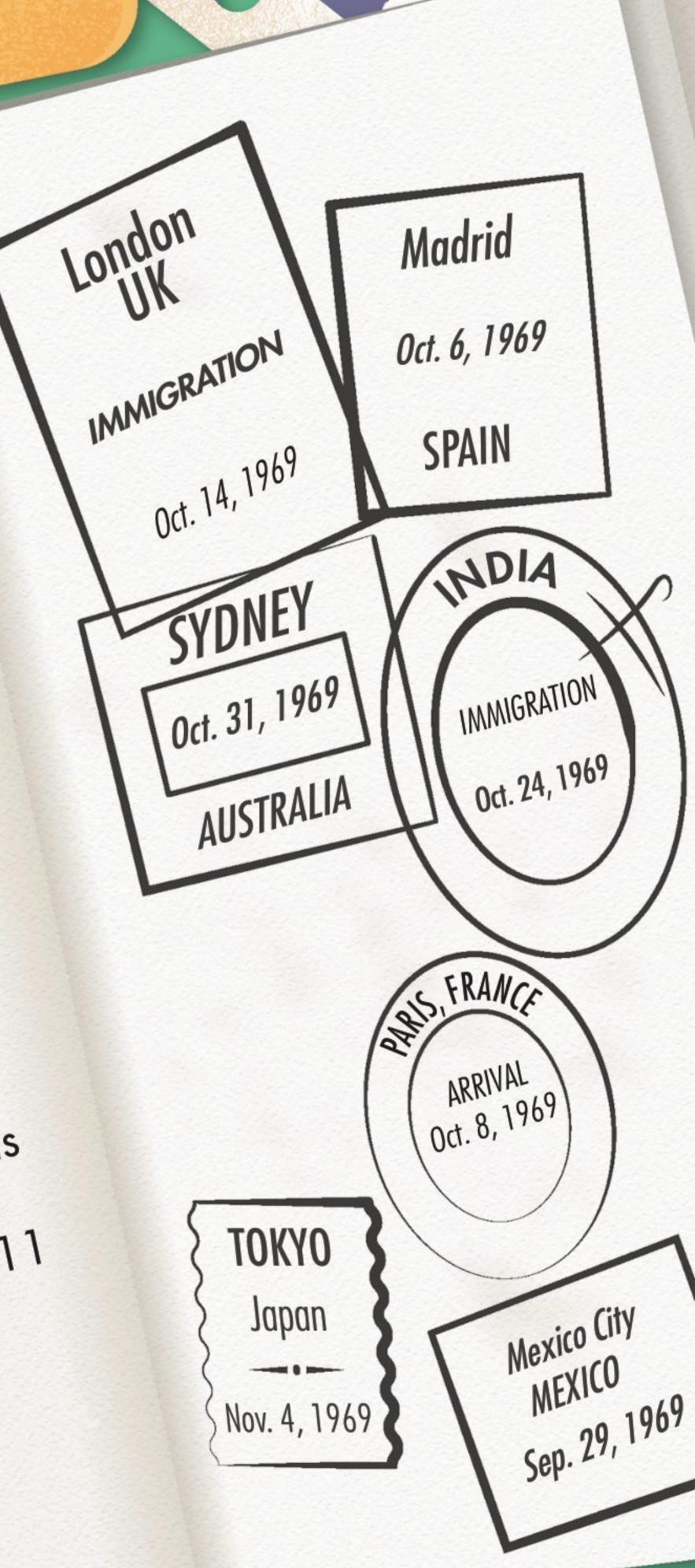
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Astronauts on tour

After Apollo 11, astronauts Neil, Buzz, and Michael became some of the most famous Michael became some of the most famous people on the planet. Everyone wanted to meet the people who had been to the moon.

Once out of quarantine, the Apollo 11 astronauts traveled through American cities astronauts as a superior constitution as a superior con

After being the first nation to successfully land people on the moon, the US wanted to share its knowledge about space travel to share its knowledge about space travel with other nations. In 45 days the group with other nations. In 45 days the group with other nations and shaking hands visited 24 different countries, meeting hands royalty and politicians and shaking hands royalty and politicians and shaking with thousands of people. This tour was officially known as the Giantstep-Apollo 1 residential Goodwill Tour.





RATION

Mexico City, Mexico The astronauts were swamped by a crowd of thousands in Mexico City. They are wearing sombrero hats and poncho capes.



Paris, France

The astronauts were presented with solid gold replicas of the Lunar Module in France, paid for by readers of the French newspaper Le Figaro.

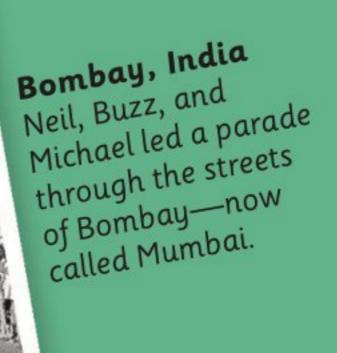


London, UK The group traveled to Buckingham Palace to meet Queen Elizabeth II and the rest of the British royal family.



Tokyo, Japan

The astronauts waved to crowds from the front of their motorcade in Tokyo. They had only recently arrived from South Korea.



Madrid, Spain At the Royal Palace of El Pardo, the group met with General Francisco Franco. He was the ruler of Spain from 1939 until 1975.



Sydney, Australia The astronauts attended a welcome reception in Hyde Park, Sydney, before giving speeches about what it was like to go to the moon.



ON APRIL 11, 1970, THEY BEGAN THEIR VOYAGE. IT WOULD BE NASA'S THIRD ATTEMPT TO SEND PEOPLE TO THE LUNAR SURFACE. HOWEVER, THE PUBLIC HAD STARTED TO BECOME BORED WITH SEEING PEOPLE ON THE MOON!

"HOUSTON, WE'VE HAD A PROBLEM."

ON APRIL 13, AFTER SWITCHING ON THE FANS
THAT STIR THE OXYGEN AND HYDROGEN TANKS
IN THE SERVICE MODULE, THE ASTRONAUTS HEARD
A BANG. THEY WERE IN SERIOUS TROUBLE. THE
OXYGEN TANK HAD EXPLODED AND THE SERVICE
MODULE WAS DAMAGED. MISSION CONTROL IN
HOUSTON ORDERED THEM TO COME HOME.



"LIFTOFF!"

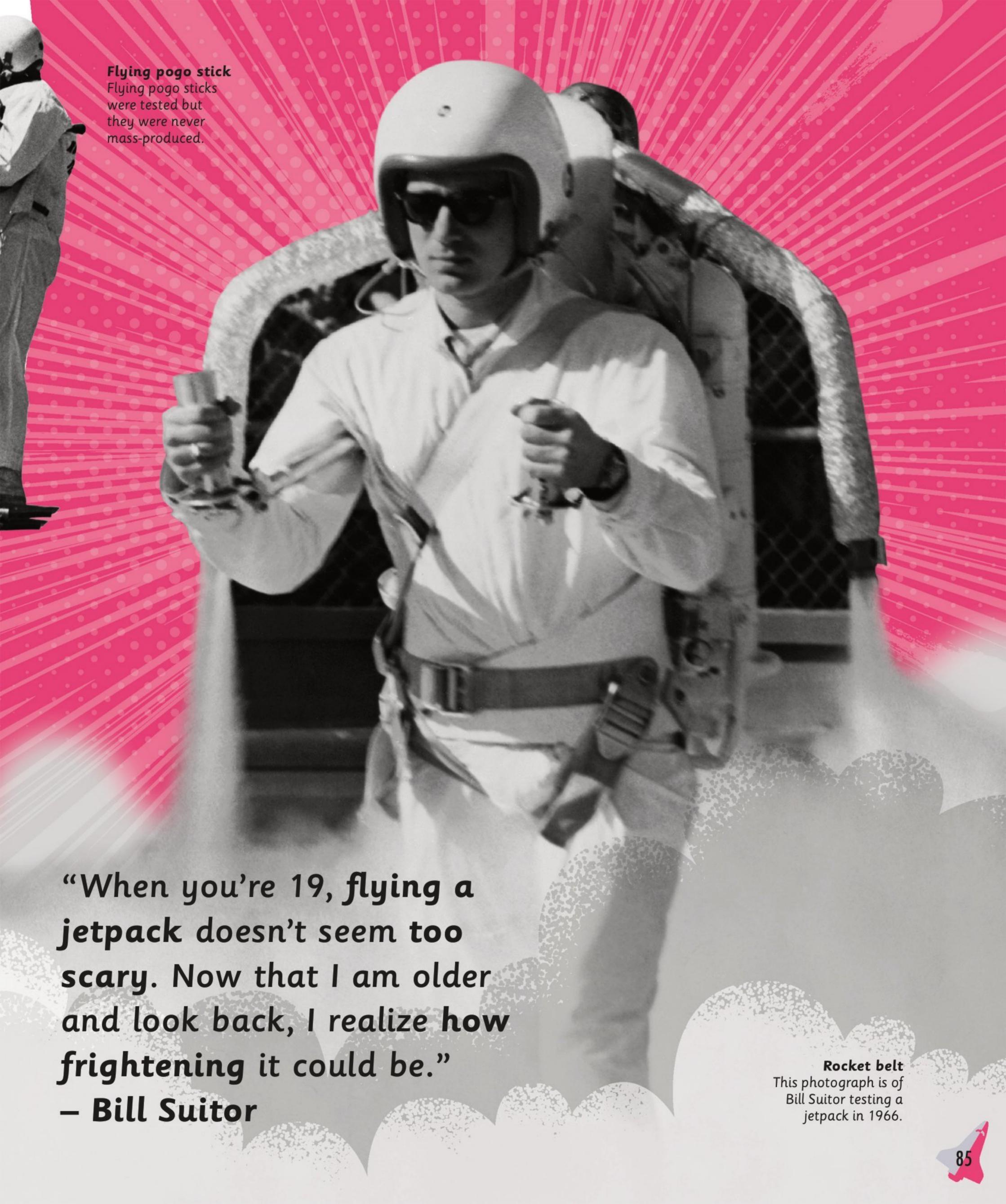


We don't have personal jetpacks yet, but during the space race they were being designed and tested. On April 20, 1961—not long after Yuri Gagarin became the first person to travel to space—the jetpack was flown for the first time. It was unveiled at Niagara Falls, on the border between the United States and Canada, and testing continued over the coming decades.

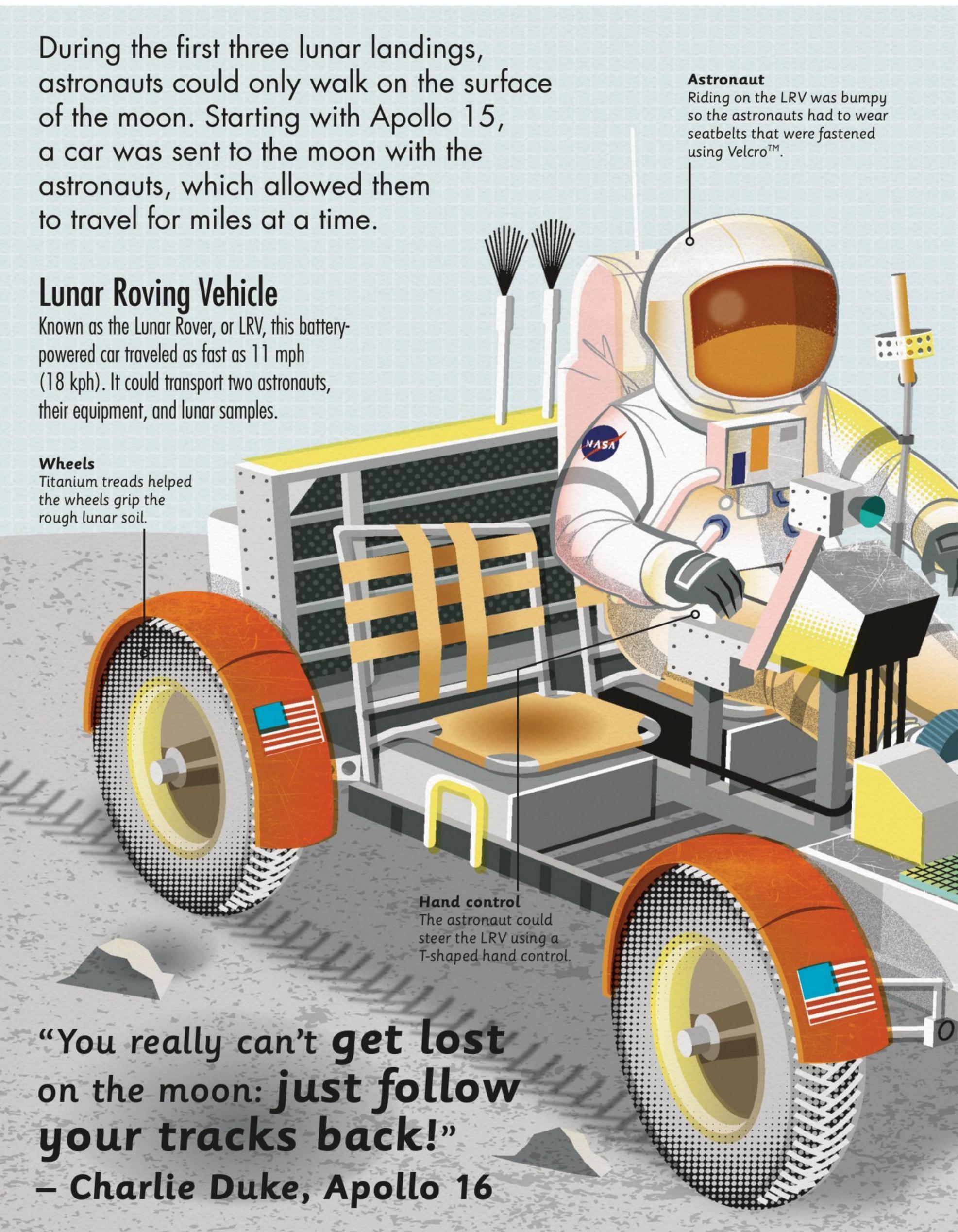
The race to the moon made people think that anything was possible, and the idea of having a personal jetpack did not seem too crazy. The jetpack, officially known as a rocket belt, was invented by Wendell Moore, an American engineer at Bell Aerosystems. He had helped to create all types of other flying devices, such as a flying chair and a two-person flying pogo stick.

One of the people who got to fly Wendell's inventions was Bill Suitor. He had known Wendell since he was a teenager, when he'd mowed his lawn. There had been hope that some of Wendell's inventions, such as the two-person pogo stick, could be used to help astronauts move around on the surface of the moon.









Antenna This large antenna was used to communicate with the team back on Earth. Television camera This camera filmed the moon in color and could be controlled by people back on Earth.

On the moon

Jim Irwin and Dave Scott — the landing crew of Apollo 15 — were the first people to drive on the moon. In this photograph, Jim salutes the American flag. The LRV is on the right.



Apollo 15 landing site

Unpacking the rover

Getting a car to the moon is incredibly difficult. The LRV, which weighed 462 lb (210 kg), was folded up in a special compartment and unpacked by the astronauts once they were on the moon.



Lowering

The astronaut lowers the LRV from the storage bay at the bottom of the Lunar Module (LM) by pulling down on straps.



Chassis unfolds

As the LRV is lowered, the frame of the rover (called the chassis) and wheels unfold.



LRV disconnects

Once the chassis is unfolded, the LRV is disconnected from the LM. Then the seats and footrest are unfolded.

S O (1)

Three astronauts traveled to the moon in each Apollo mission, but only two of them would walk on its surface. The other astronaut—known as the Command Module Pilot—had to remain orbiting the moon, all alone.

The role of the Command Module Pilot was very important. They had to look after the Command/Service Module (CSM), which was the crew's only way to get back to Earth, and to study the moon from above. In the event of a catastrophic failure on the moon, they would have to return to Earth alone, although fortunately this never happened. In the later Apollo missions, the Command Module Pilot even got to perform a space walk to retrieve camera film that had been left on the outside of their spacecraft.

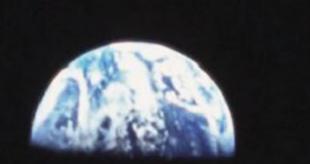
As the CSM passed around the far side of the moon, its pilot would be completely cut off from all communications. This made the Command Module Pilots completely isolated. However, they didn't have time to feel lonely—they were kept busy with tasks to complete before they met up with the other astronauts. In the blackness of space, they could also look out into the universe and see more stars than they could ever count.



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What did Command Module Pilots do?

OPERATIONS CHECKLIST

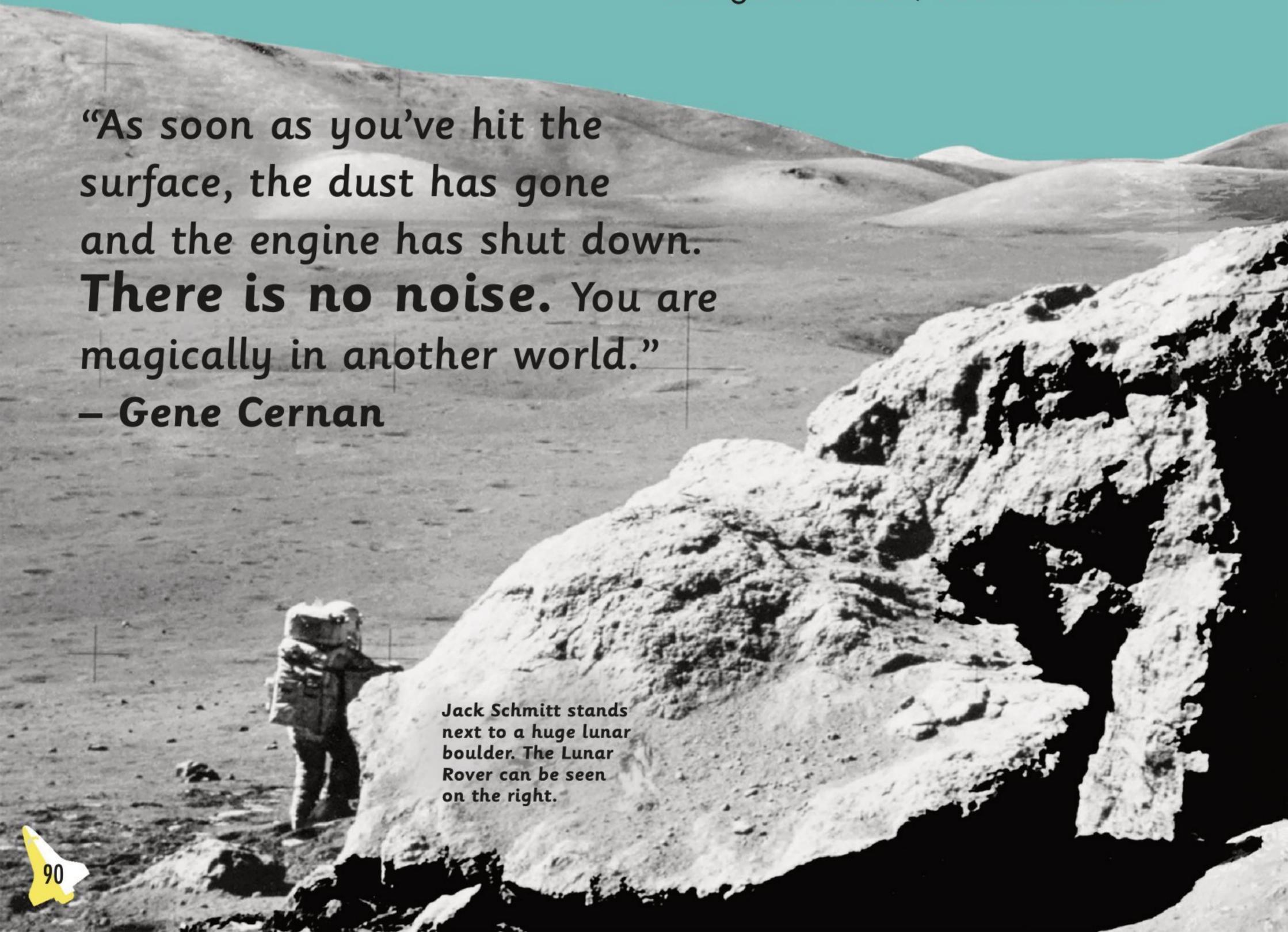
- 1. Know all the systems on the Command/Service Module (CSM)
- 2. Serve as flight engineer during the launch
- 3. Navigate and perform course corrections on the journey
- 4. Pilot the CSM while orbiting the moon
- 5. Photograph the surface of the moon from the CSM
- 6. Look for landing sites for future Apollo missions
- 7. Rescue the Lunar Module if it cannot dock in space

The last mission

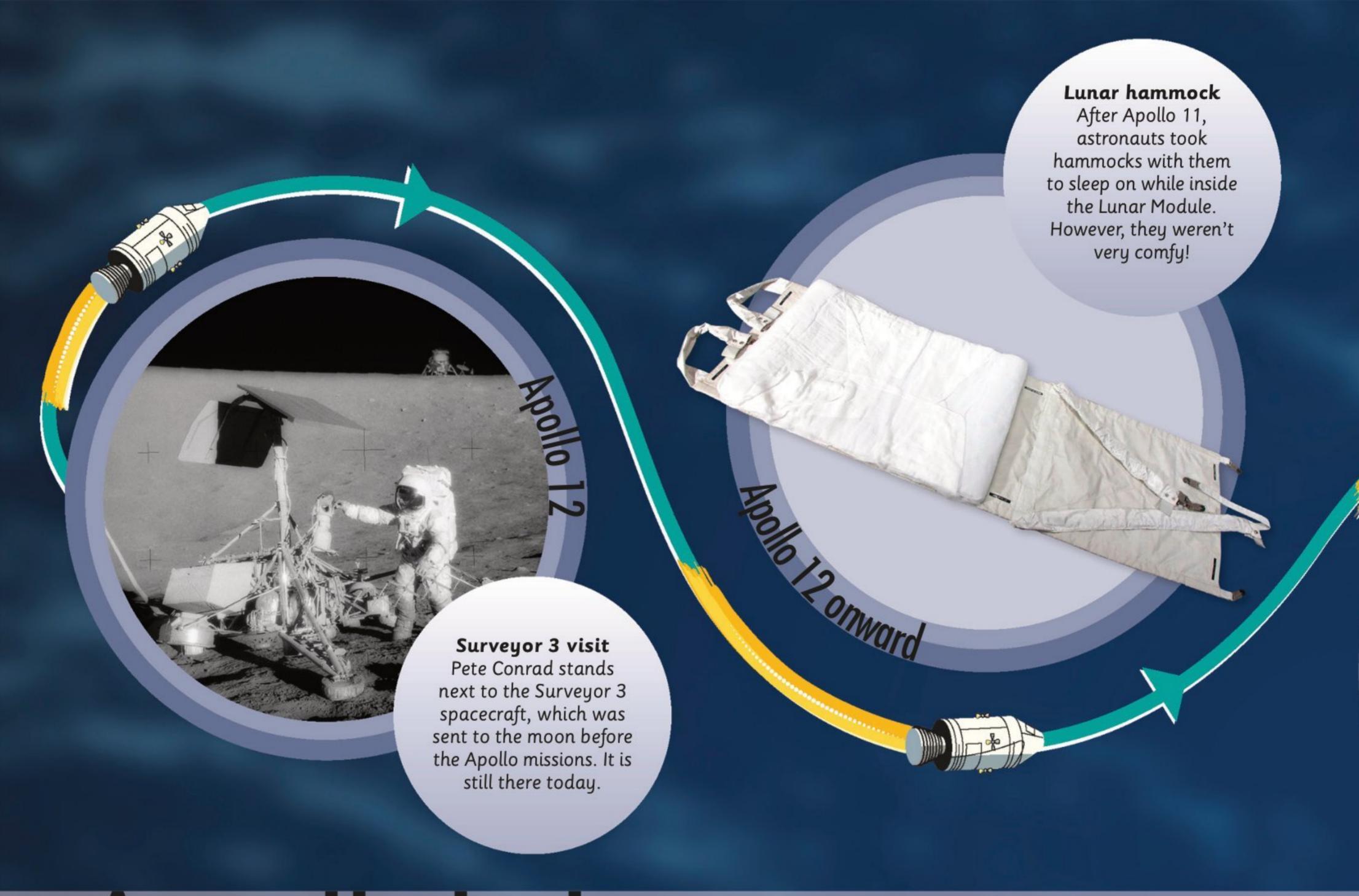
In December 1972, Apollo 17 was the last mission to the moon. Originally, 10 moon landings had been planned. However, due to cuts in funding, only six went ahead.

For Commander Eugene "Gene" Cernan, being in charge of the final mission was the proudest moment of his life. He was joined by Lunar Module Pilot Harrison "Jack" Schmitt, the only scientist to visit the moon, and Command Module Pilot Ronald Evans.

Apollo 17 spent three days on the moon exploring a valley called Taurus-Littrow, where they discovered orange soil. Later, scientists would





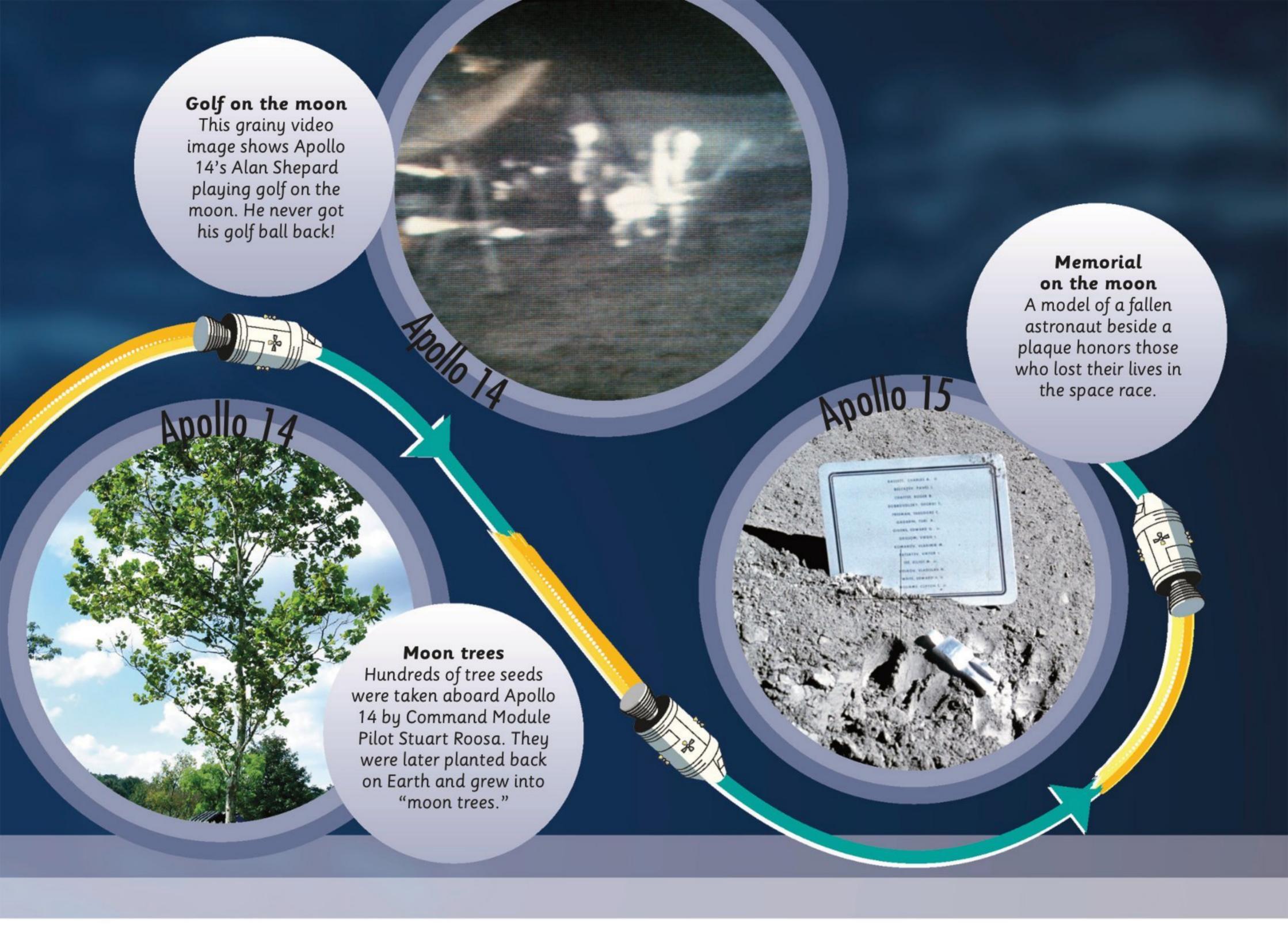


Apollo's legacy

The Apollo missions changed the way we saw the moon forever. In total, astronauts brought back 842 lb (382 kg) of lunar rocks, pebbles, and dust. These samples are still being studied by scientists to this day. They have helped us understand more about the history of the moon, but also more about the Earth. For example, most scientists now think that the moon

was formed when a young Earth was struck by a Mars-sized object.

Soil samples collected by the Apollo astronauts have also helped scientists learn more about the sun's activity over many millions of years. This is because the moon doesn't have a protective atmosphere to block the sun's stronger rays, like Earth does, so we can see how these rays have left their mark on lunar rocks.



The findings are pieces in a jigsaw puzzle as we try to piece together our understanding of not only the Earth and the solar system, but also the universe around us. We are only just beginning to scratch the surface of what is to come, but Apollo has given us a great start.

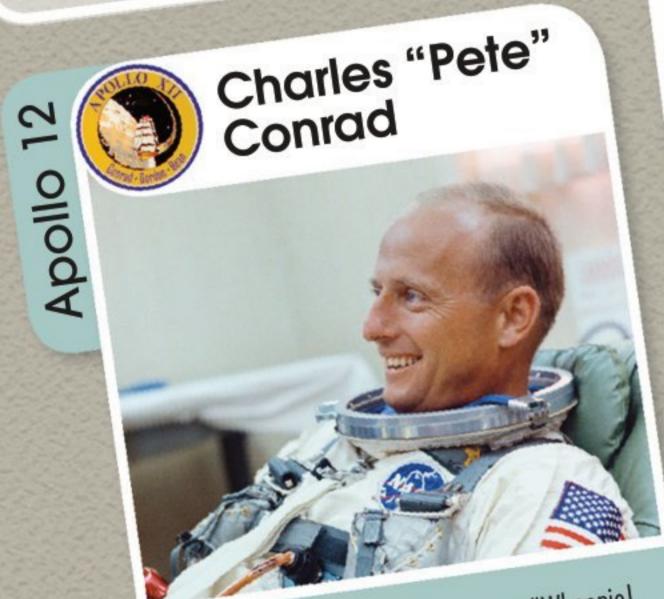
However, Apollo was as much about people as it was about science.
When future explorers return and

visit the landing sites, they will find all sorts of treasures. They will read plaques detailing how people "came in peace for all mankind," find the Lunar Rovers that astronauts enjoyed driving on the surface, and they might even find Alan Shepard's missing golf ball! To this day, Apollo is the greatest story in human exploration.

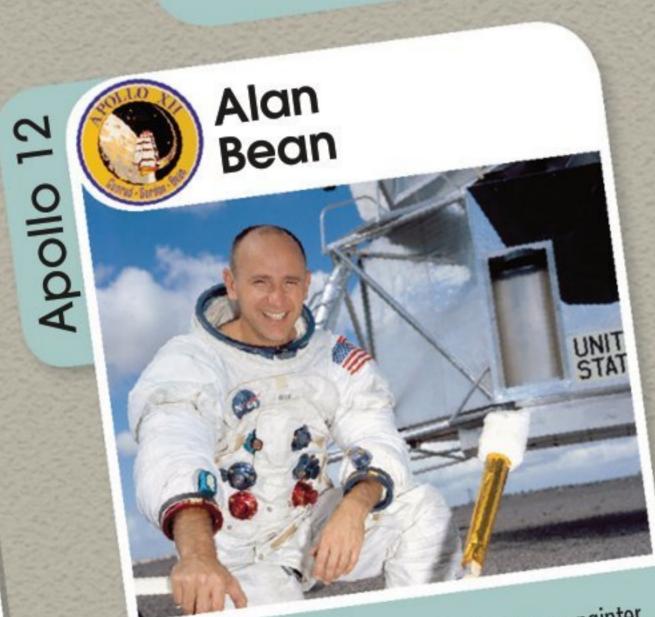
Footprints on the moon

Out of every human that has ever existed, only 12 have walked on the moon.

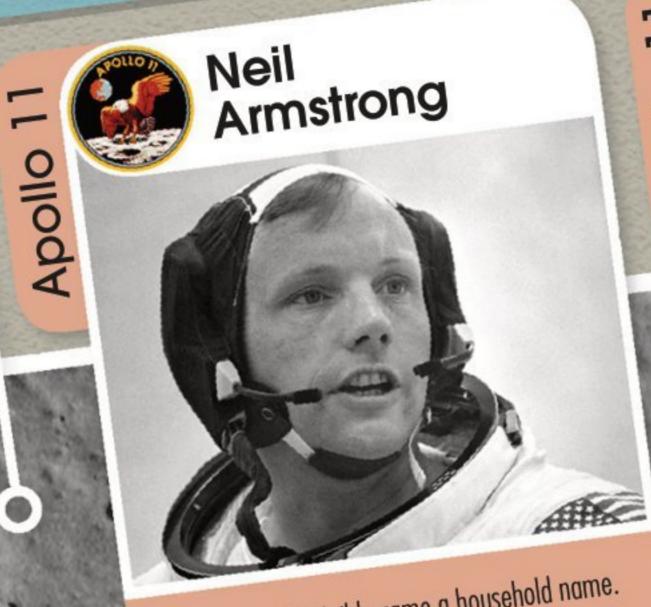
Landing site map This is a photograph of the Apollo 17 landing site, taken by NASA's Lunar Reconnaissance Orbiter (LRO) in 2011. You can see footprints, tire tracks, and the descent stage of the Lunar Module.



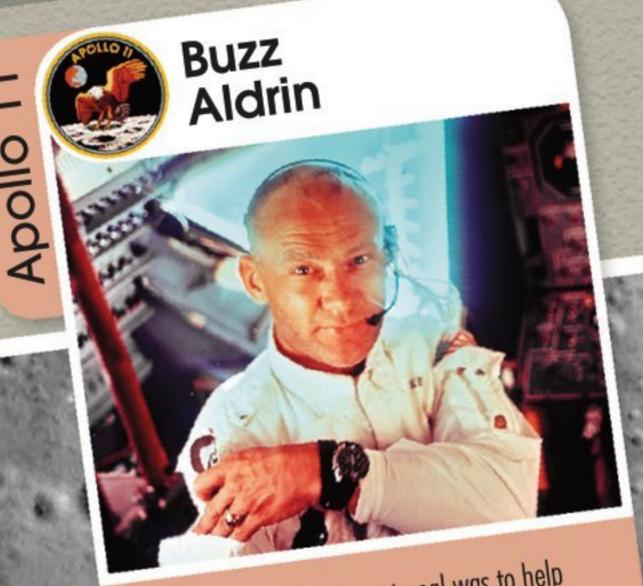
Pete's first words on the moon were: "Whoopie! Man, that may have been a small one for Neil, but that's a long one for me."



After walking on the moon, Alan became a painter, inspiring others with his lunar landscapes.



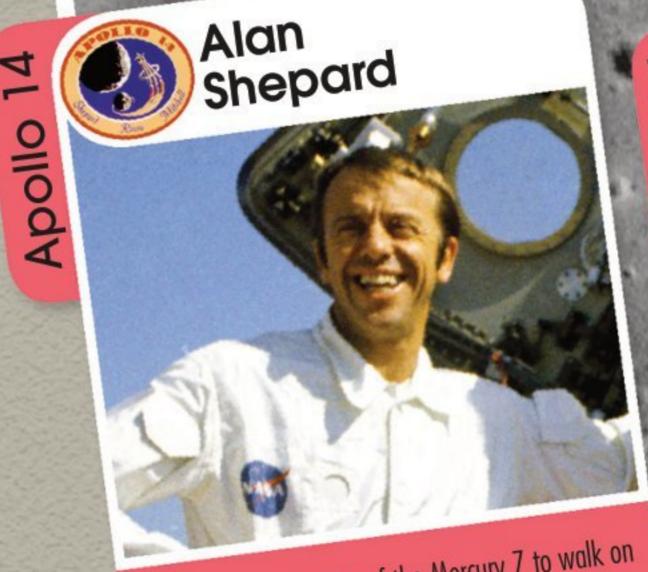
After Apollo 11, Neil became a household name. However, he avoided the spotlight and returned to his passion—flying planes!



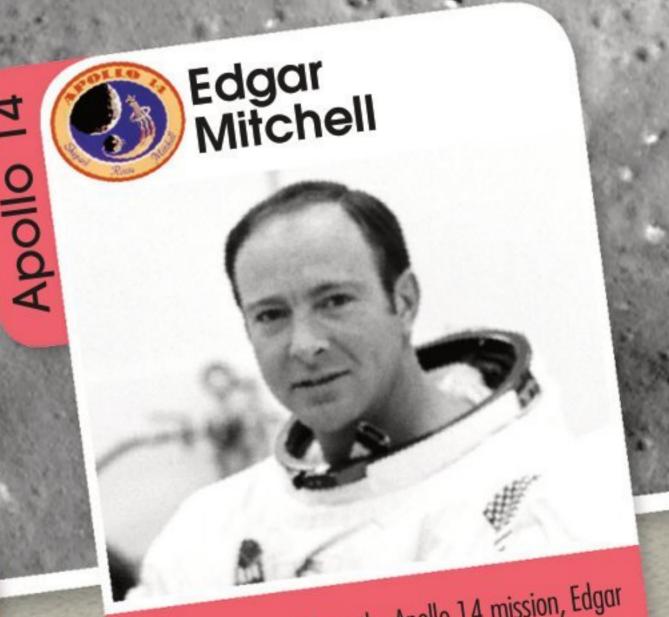
After the moon, Buzz's next goal was to help humans get to Mars. He traveled the world inspiring others about the Red Planet.

Astronauts' footprints

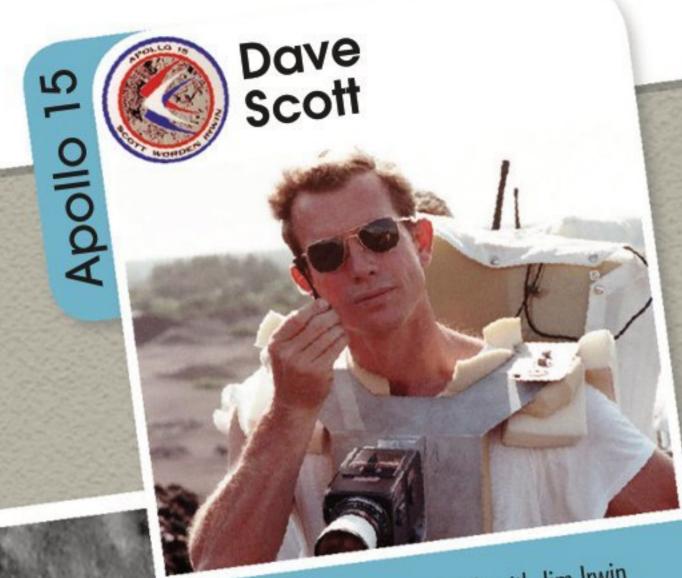
> Descent stage of Lunar Module



Alan was the only one of the Mercury 7 to walk on the moon. While there, he hit a golf ball, which he said traveled for "miles and miles."



When he returned from the Apollo 14 mission, Edgar helped found the Association of Space Explorers to be a member you have to have gone to space!



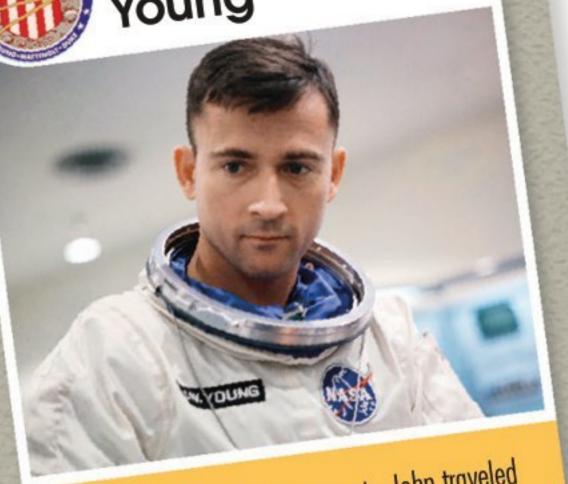
During an Apollo 15 moonwalk with Jim Irwin, Dave discovered a moon rock that was four billion years old!

Jim Irwin Apollo



From the surface of the moon, Jim looked back at Earth and described it as "beautiful and fragile."

John Young Apollo



One of NASA's greatest astronauts, John traveled to space a total of six times and was the first person to fly the Space Shuttle.

Tire tracks



At 36 years old, Charlie was the youngest astronaut to walk on the moon.

Family photo on the moon Charlie Duke left this photograph of his family on the moon. Another astronaut, Gene Cernan, scratched his daughter's

initials on the moon's surface on a

separate mission.

Eugene "Gene" Cernan Apollo



Gene was the last person to walk on the moon. He dedicated his life to promoting space exploration, hoping that people would walk on the moon again. Harrison "Jack" Schmitt



Jack was the only scientist to walk on the moon. After Apollo 17 he became a US senator.



Astronauts may have been the public face of Apollo, but behind them was a team of about 400,000 people.

There were the women who handstitched every spacesuit, the janitors who made sure the spacecraft were clean, and the scientists and engineers who worked hard to solve seemingly impossible problems to put rockets into space. Every single job mattered, and everyone had to do their part to make sure that the Apollo missions were successful.

Scientists and engineers from all around the world helped during the Apollo missions. And countries



as far away as Australia, the United Kingdom, and Spain helped to track every Apollo spacecraft on its journey.

There are too many quiet heroes to name. One of the greatest lessons to come from the space race and Apollo is that when a group of experts

work together as a team, they can achieve more than if they work alone.

While the astronauts who walked on the moon were able to look up and say "I went there," thousands of other people were able to look at the moon in a different way, knowing that they helped to send people there.

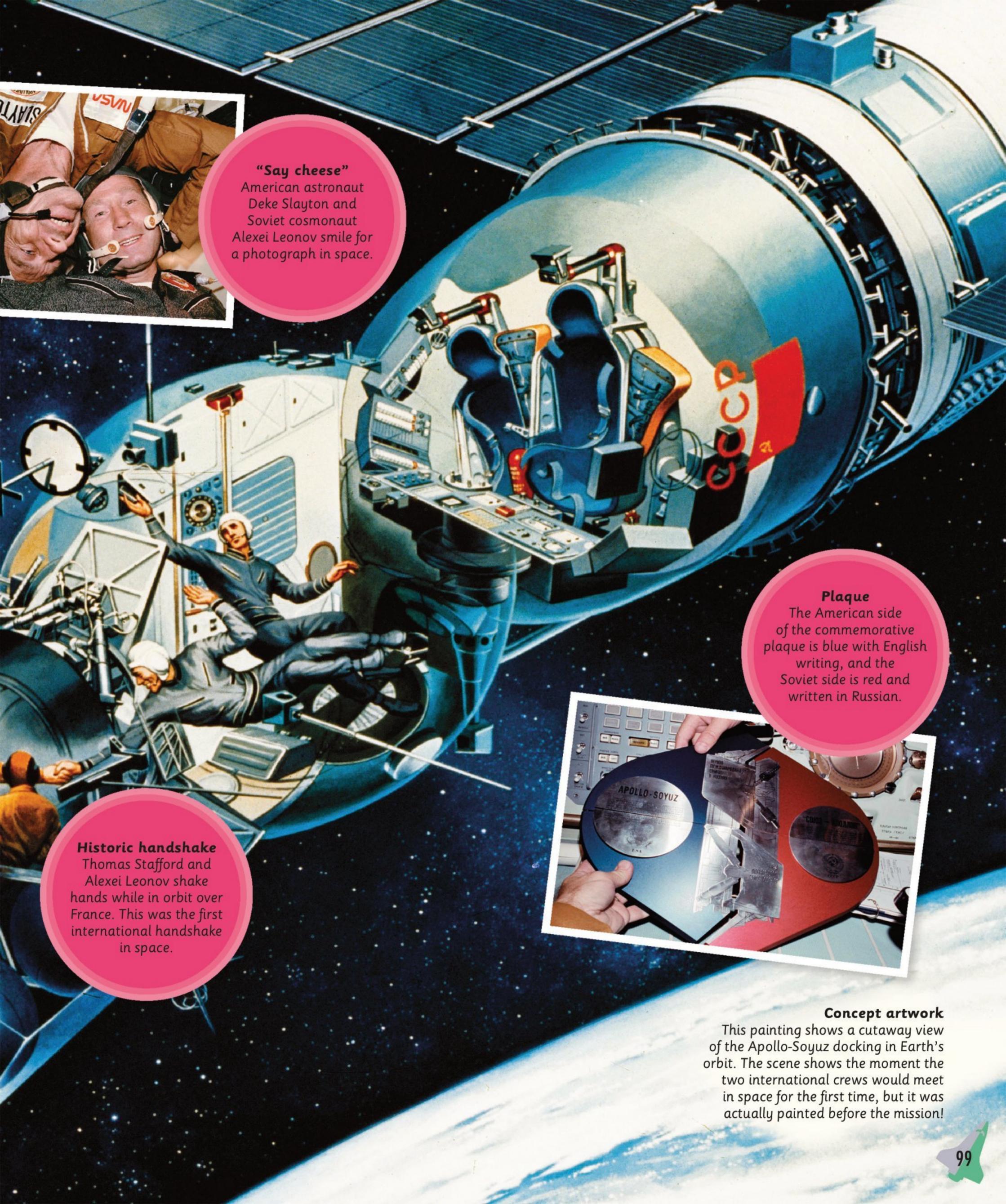


On July 17, 1975, an American Apollo spacecraft and a Soviet Soyuz spacecraft joined together in space. After they docked, the commanders of each crew floated through the connecting hatch and shook hands. This moment was watched by millions of people on Earth, as the docking marked the end of the space race between the US and the Soviet Union. These competing nations could now work together to explore space.

The mission was made up of two crews—Soviet cosmonauts Alexei Leonov and Valery Kubasov, and American astronauts Thomas Stafford, Deke Slayton, and Vance Brand. They took phone calls from both American President Gerald Ford and Soviet leader Leonid Brezhnev. The crews also performed science experiments together and exchanged gifts.

Soviet leader Leonid Brezhnev. The crews also performed science experiments together and exchanged gifts.

The group assembled a plaque to mark their joint mission, with one side made in the US and the other made in the Soviet Union. After two days together, the crews said their goodbyes, undocked, and set off on separate space missions before returning home.



What the Soviets did next

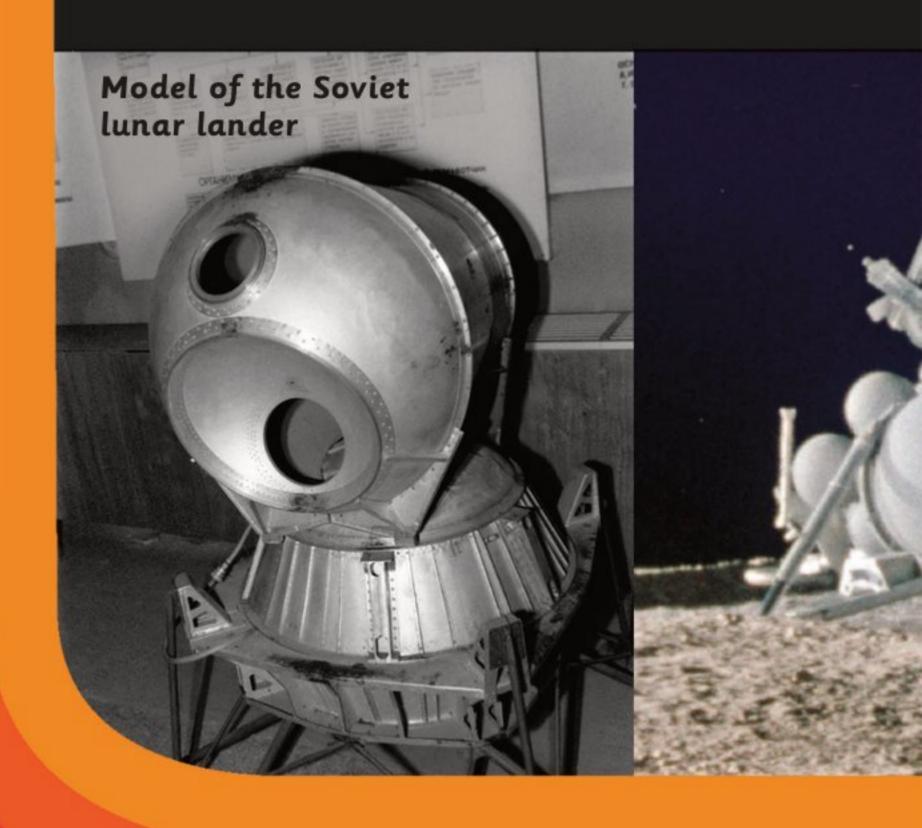
Many people thought the Soviet Union would be first to send people to the moon. They'd had many successes in space—they sent the first spacecraft to the moon and, later, were the first to photograph the far side of the moon. In September 1968, they even sent tortoises around the moon, before returning them safely to Earth.

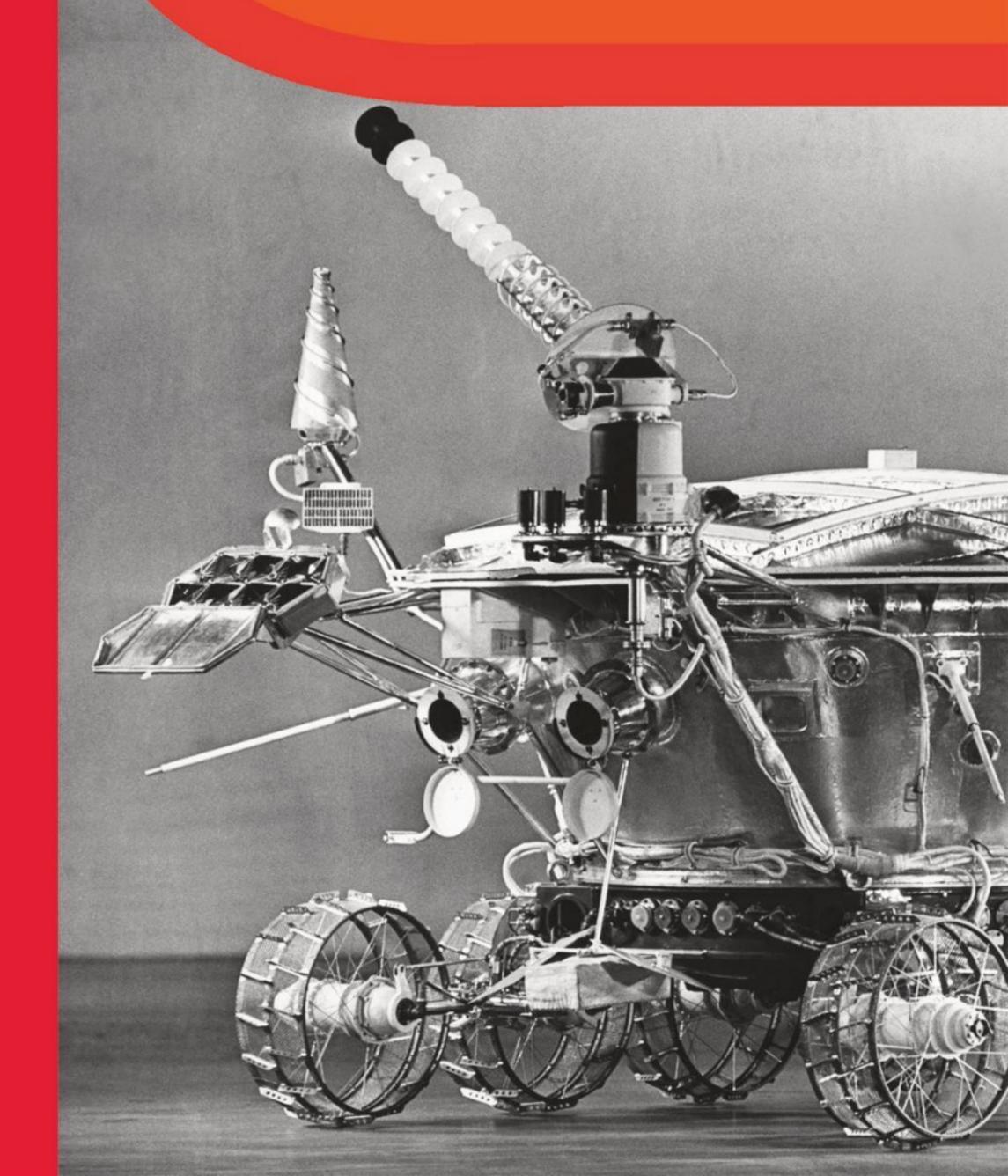
However, the Soviets never succeeded in sending a crewed spacecraft to the moon. Instead, following Apollo 11, they focused on robotic missions, which were cheaper to carry out.

They sent robotic spacecraft to other planets and were the first to send back photos from the surface of Venus. They also created the first space stations, designed for people to live and work in space.

Soviet lunar lander

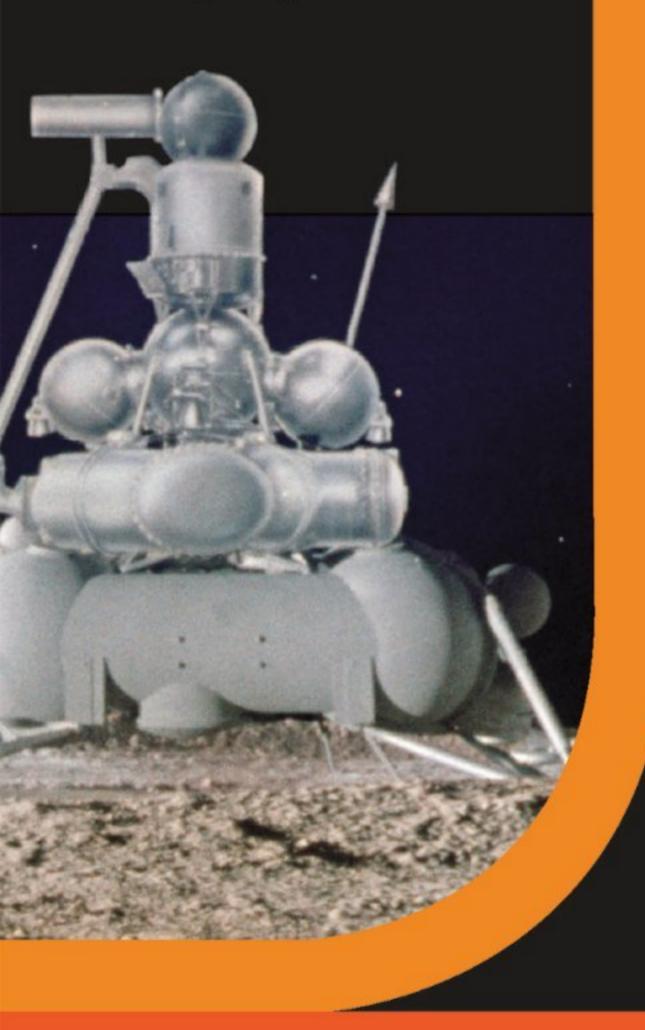
The Soviets designed a lander to put a person on the moon, but it was never used. Instead, they sent a robotic probe, called Luna 16, which returned to Earth with a sample of lunar soil.







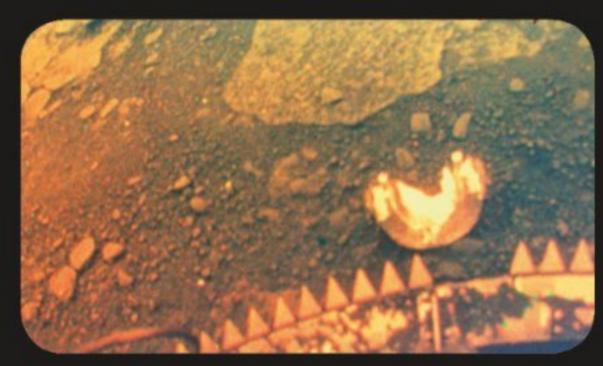
An artist's impression of Luna 16 on the surface of the moon



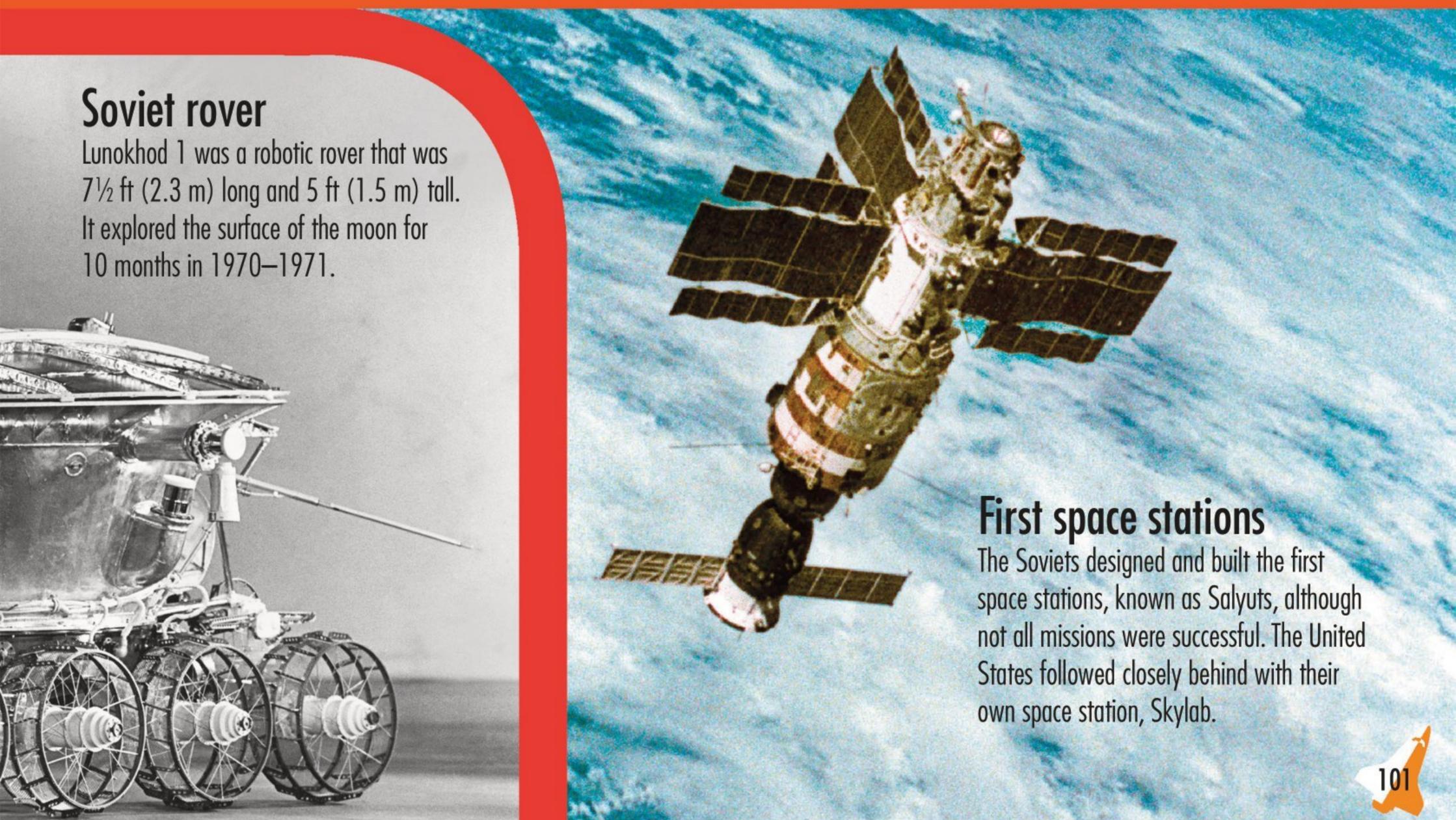


Exploring Venus

The Soviets were initially more successful than the United States at exploring the planet Venus's surface. Between 1970 and 1985 they landed several spacecraft there, including the Venera spacecraft, as celebrated on this stamp. The Venera spacecraft sent back photographs from the surface.



Color photo of Venus's surface, taken by Venera 13 in 1982



The Voyager missions

Our curiosity about space did not end with the Apollo program. In fact, Apollo was just the beginning of our space adventure. In 1977, NASA launched twin robotic spacecraft called Voyager 1 and

Voyager 2. They were sent on a journey across our solar system to explore the outer planets. They traveled to places no human-made object had ever been to before, and are still on their journey to this day!

Spacecraft *

The Voyager spacecraft were

designed so that they could

send messages back to Earth

from beyond our solar system.

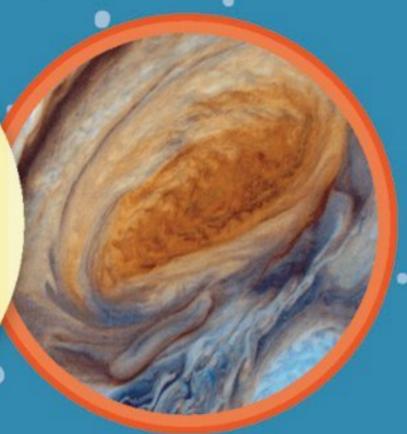
Launch

Voyager 1 lifts off from Cape Canaveral in Florida. It is named Voyager 1 because it would be the first spacecraft to reach Jupiter and Saturn.



Jupiter

Voyager 1 reaches Jupiter. It takes images that reveal that Jupiter's Great Red Spot is actually a huge storm. It also discovers volcanoes on Jupiter's moon, lo.



September 5, 1977

Voyager 1

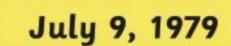
November 9, 1980

Voyager 2

August 20, 1977



Voyager 2 launches into space from Cape Canaveral. It launched before Voyager 1, but it is named Voyager 2 because it would reach Jupiter and Saturn after Voyager 1.



March 5, 1979

Jupiter

Voyager 2 takes images of Jupiter's ring system and observes volcanic eruptions on Jupiter's moon, lo.

August 25, 1981

Saturn

Voyager 2 has its closest encounter with Saturn. It photographs the planet and flies by some of its icy moons, including Tethys and lapetus.



.

The Golden Record

If aliens ever discover one of the Voyager spacecraft, they will find a Golden Record. This record contains sounds and greetings from Earth, showing what life is like here. It's a little bit like the cosmic equivalent of a message in a bottle!



Saturn

Voyager 1 photographs
Saturn and its largest
moon, Titan. The spacecraft
also discovers three new
moons around the
planet: Atlas, Pandora,
and Prometheus.



Some 3.7 billion miles (six billion km) away from the sun, Voyager 1 takes a photograph of Earth, which looks like a tiny, pale blue dot.

Beyond our solar system

Voyager 1 becomes the first human-made object to leave the solar system.

February, 14 1990

August 25, 2012

January 24, 1986

August 25, 1989

Uranus

Voyager 2 becomes the first and only spacecraft to visit Uranus. Images taken by the spacecraft reveal what the planet looks like up close.

Neptune

At Neptune, Voyager 2
discovers six new
moons and a giant
storm on the planet,
nicknamed the "Great
Dark Spot."



The start of the 1980s saw a new type of mission for NASA astronauts—leaving Earth using the Space Shuttle. While earlier spacecraft could be used only once, the Space Shuttle was designed for many flights.



Liftoff!

The Space Shuttle came in three parts: the Orbiter, which housed the astronauts; a large orange fuel tank called the External Tank; and two Solid Rocket Boosters, which blasted the Shuttle into space.

Heat shield
Tiles on the edges of the wings
and the underside of the Orbiter
protected it from extreme heat

during reentry.

Space Shuttle Main

Engines (SSME)

Three main engines

helped to push the

Shuttle into orbit

and steer it in the

right direction.

Astronauts could go outside through an airlock to perform spacewalks.

Rudder

The rudder was used

to help slow down the

Orbiter before landing.

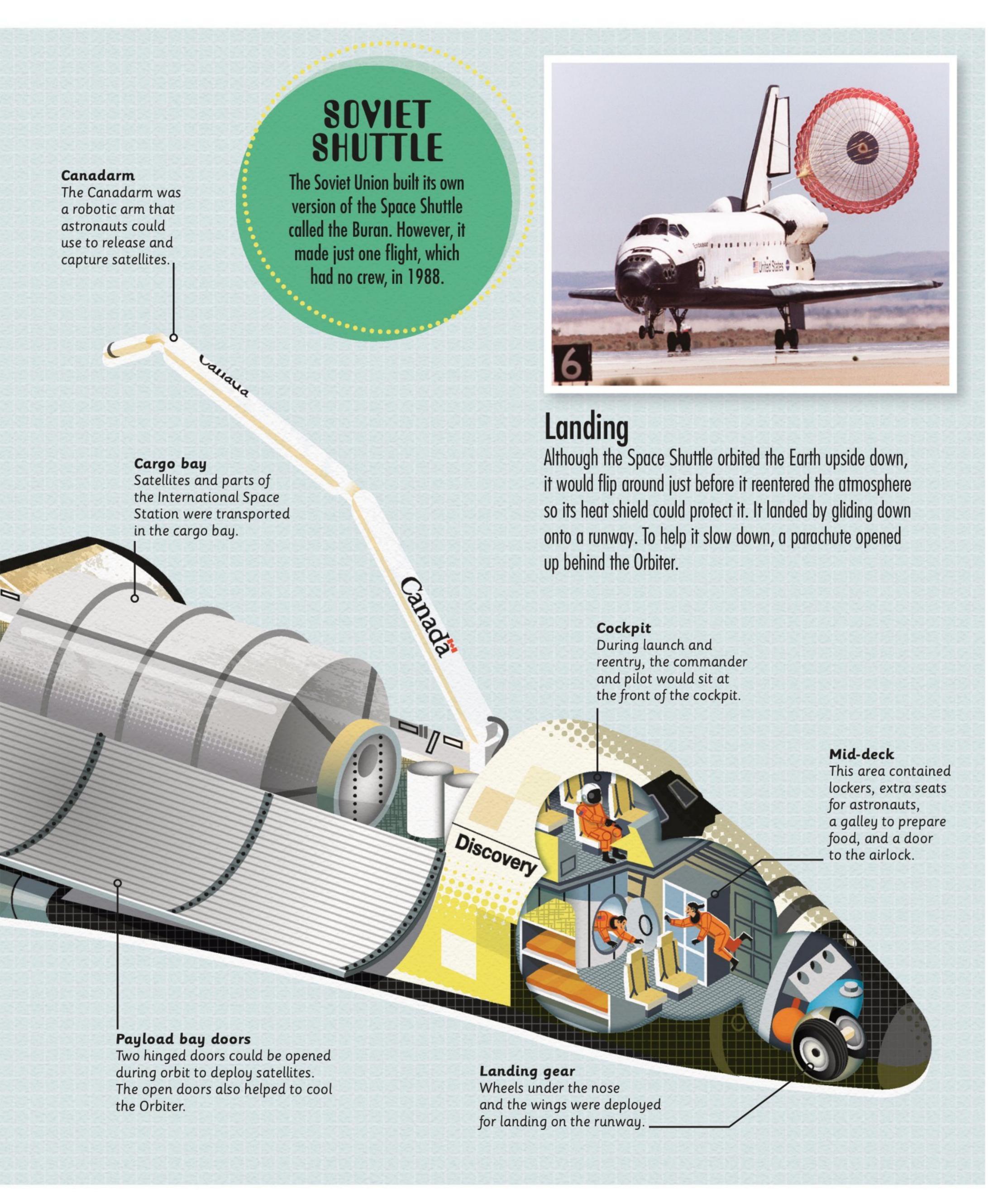
Fuel tanks

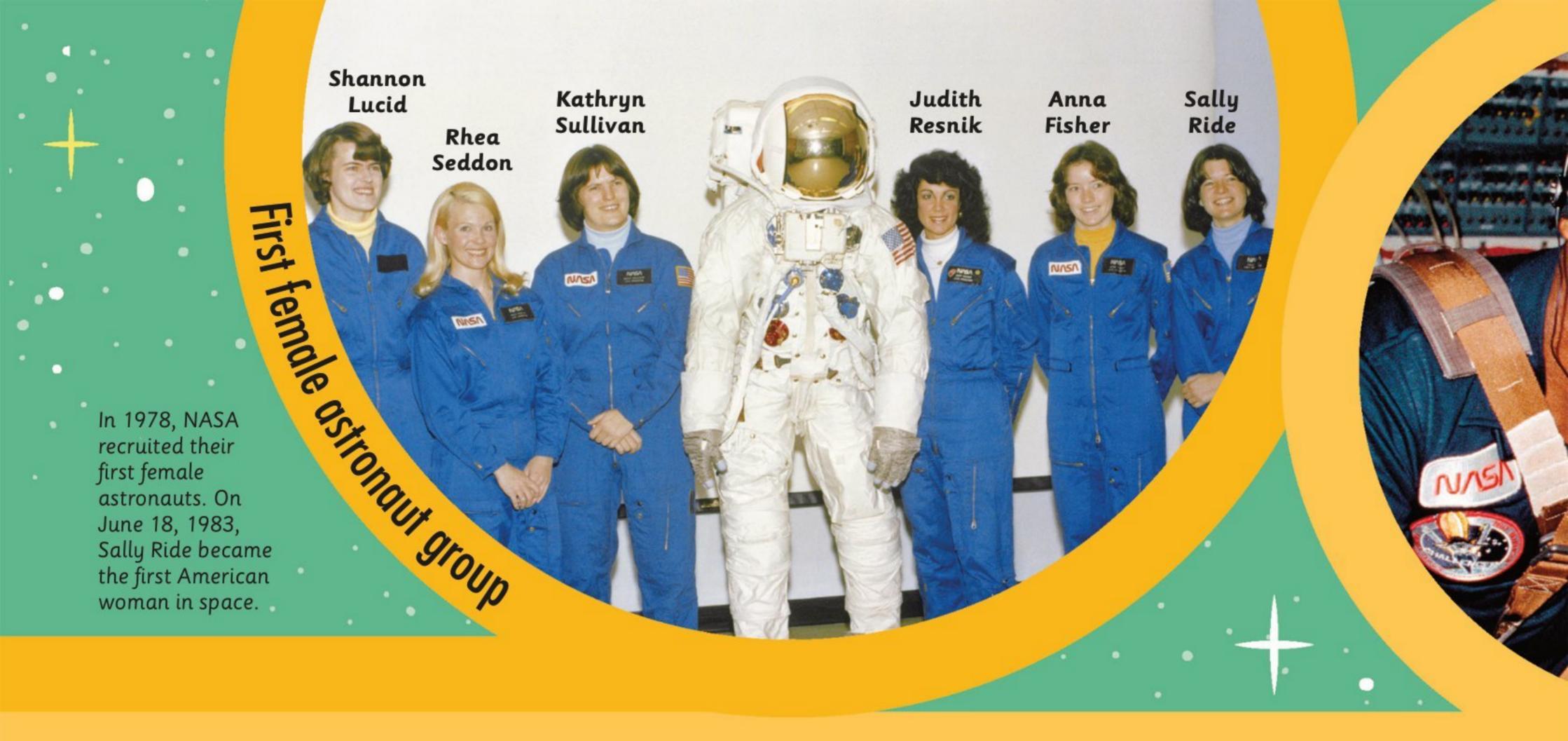
Fuel for the

was stored

in two tanks.

main engines





A new generation

The Space Shuttle era paved the way for a new generation of NASA astronauts. In the past, all of the astronauts had been men, and most were military test pilots. However, society was changing and becoming more inclusive, and there were now more opportunities for African Americans, like Guion Bluford, to go to space.

For the first time, NASA recruited women with the intention of sending them to space. Among them was Judith Resnik, who had trained as an

electrical engineer. The first female astronauts were selected in 1978, and they helped to inspire more women to go to space.

Space also started to become more global. More countries wanted to be involved so that they could benefit from new discoveries in science and technology. Although the Soviet Union and the US were still the only nations that could send people to space, both would fly astronauts from other countries, such as Saudi Arabia, the United Kingdom, and India.





The Soviet Union began construction on the space station Mir in 1986. Meaning "peace" in Russian, Mir was assembled in space over a period of 10 years. In its day, it was the largest human-made object in orbit.

More than 100 people visited Mir during its 15 years in space. For some of them, it was their home for several months. The visitors carried out lots of experiments and increased our understanding of what happens to the human body after a long time spent in space.

During Mir's lifetime, the political world back on Earth changed dramatically. In 1991, the Soviet Union fell apart when its leader, Mikhail Gorbachev, stepped down, and Russia and several other nations were formed. The cosmonauts aboard Mir at that time returned home to a very different country. This change led to a new collaboration in space between the United States and Russia. Both the US Space Shuttle and the Russian Soyuz took people to Mir, and the two countries began working together in space regularly.

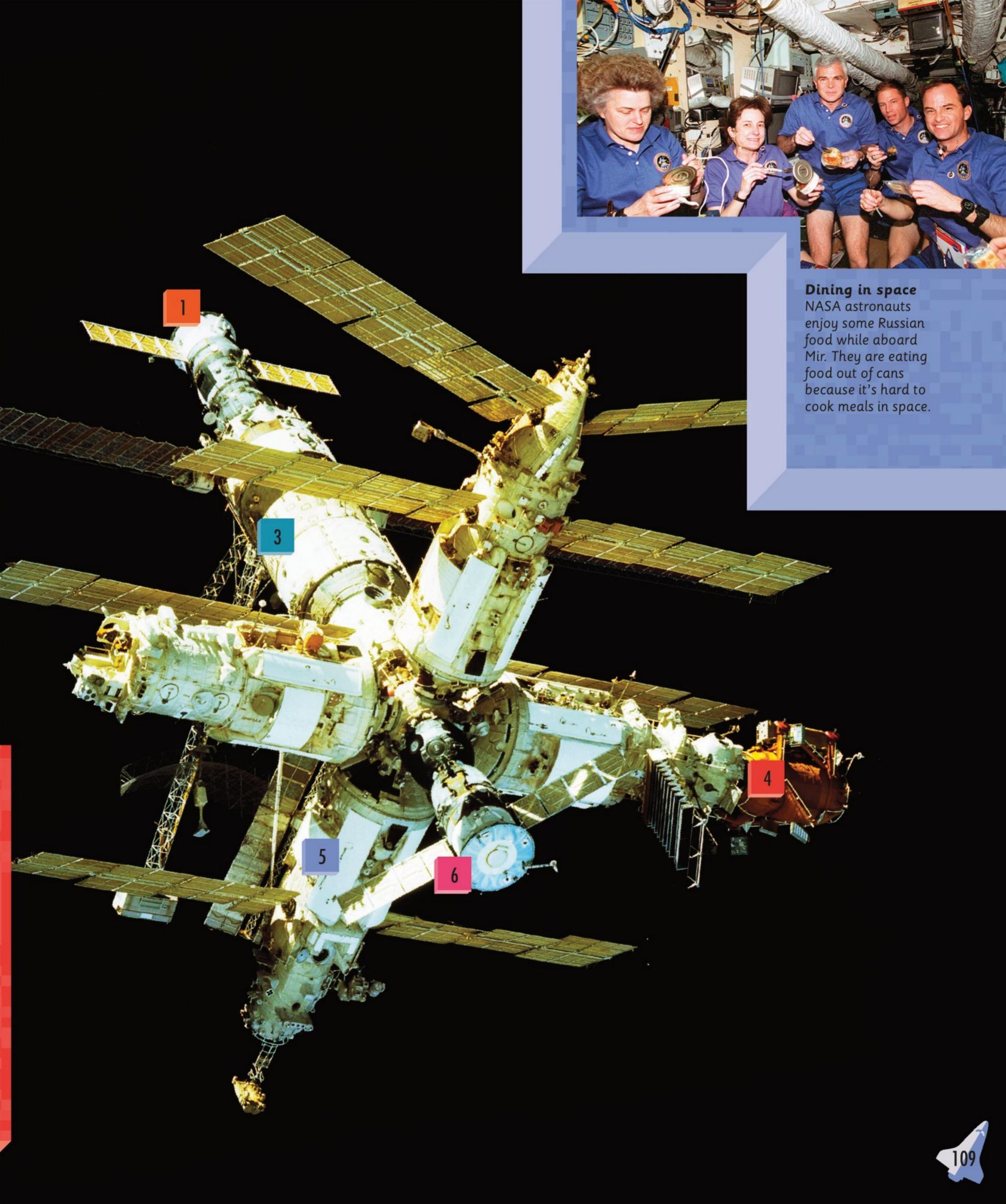
Key

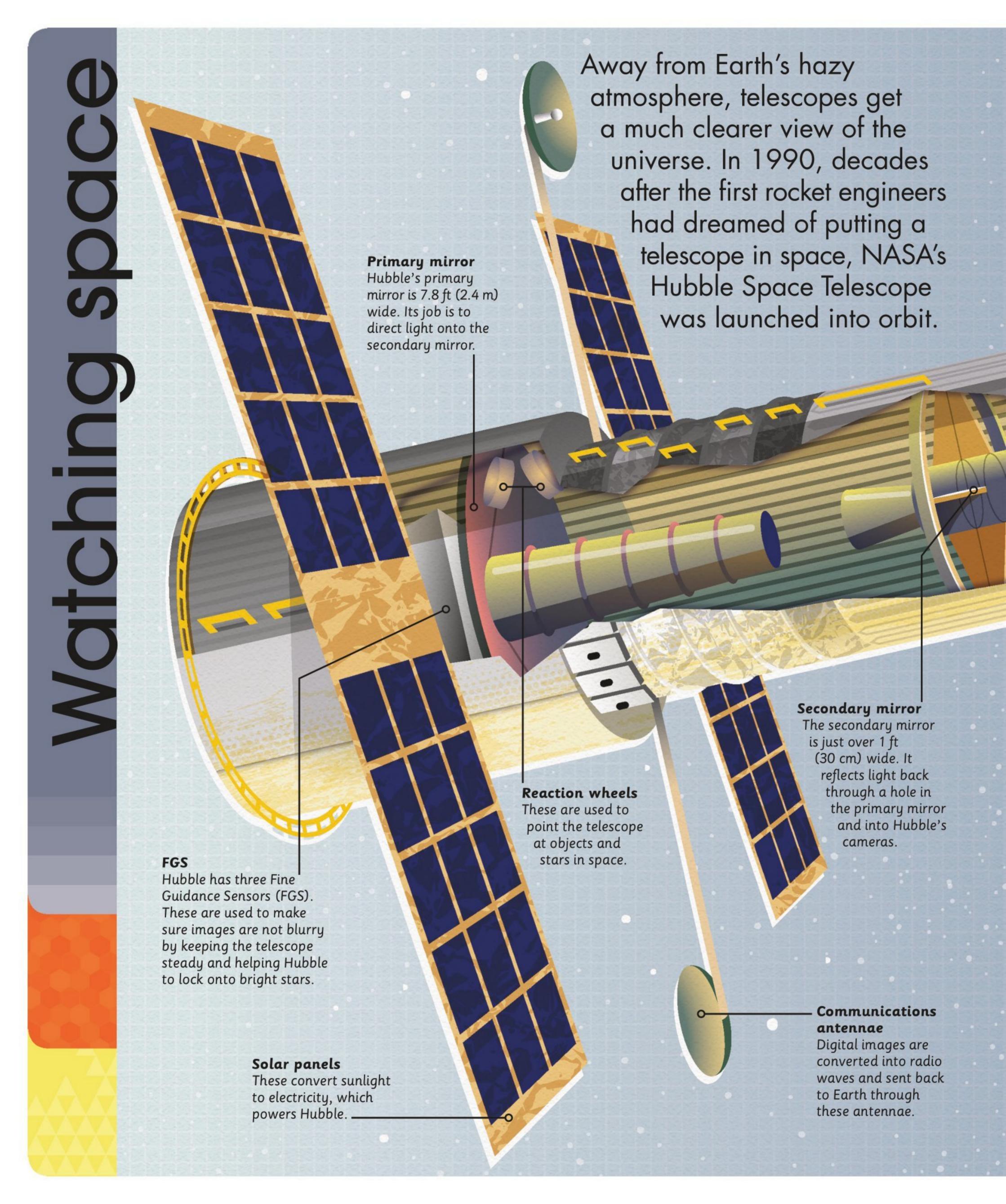
- Progress spacecraft
 The spacecraft was used to carry supplies, but not crew, to Mir.
- 2 Solar arrays
 These panels used sunlight to generate power.
- Core module
 This was the heart of the space station. It contained the living quarters.
- 4 Kristall docking module
 This allowed the NASA Space
 Shuttle to dock with Mir.
- 5 Kvant-2
 This module had an airlock used for space walks.
- Soyuz spacecraft
 This Russian spacecraft
 was used to take crew
 and supplies to Mir.

2



Life on Mir Cosmonauts and astronauts have fun posing for a group photo. Life on Mir had its problems, too, including a dangerous fire in 1997.





Aperture door If needed, the aperture door can close to prevent bright sunlight from damaging the telescope.

Servicing Hubble

To service the Hubble Telescope, the Space Shuttle flew alongside it, grabbed onto it with a robotic arm, and put it in the Shuttle's cargo bay. From here, astronauts could repair it and replace faulty parts.



Photos

The Hubble Space Telescope has given us some of the most incredible pictures of the universe. It has taken hundreds of thousands of photos, showing stars being born and galaxies that are really far away.

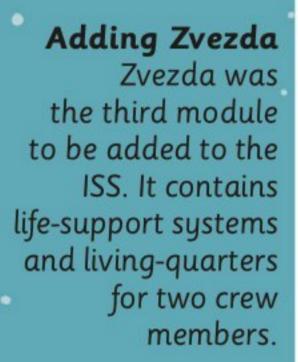


Tarantula Nebula This photo is of one of the Milky Way's nearest neighbors, the Tarantula Nebula.

Lagoon Nebula Taken to celebrate Hubble's 28th birthday, this photo centers on a star that is 200,000 times brighter than our sun.



Zarya
The first part of
the space station,
or module, to be
launched was Zarya.
Built in Russia, it
provided electrical
power and storage
during the assembly
of the ISS.







Getting bigger
By 2005, the ISS had a science laboratory, airlocks, and Canadarm2—a robotic arm for moving equipment around.

Further expansion

More solar panels were
added to the ISS in 2007.

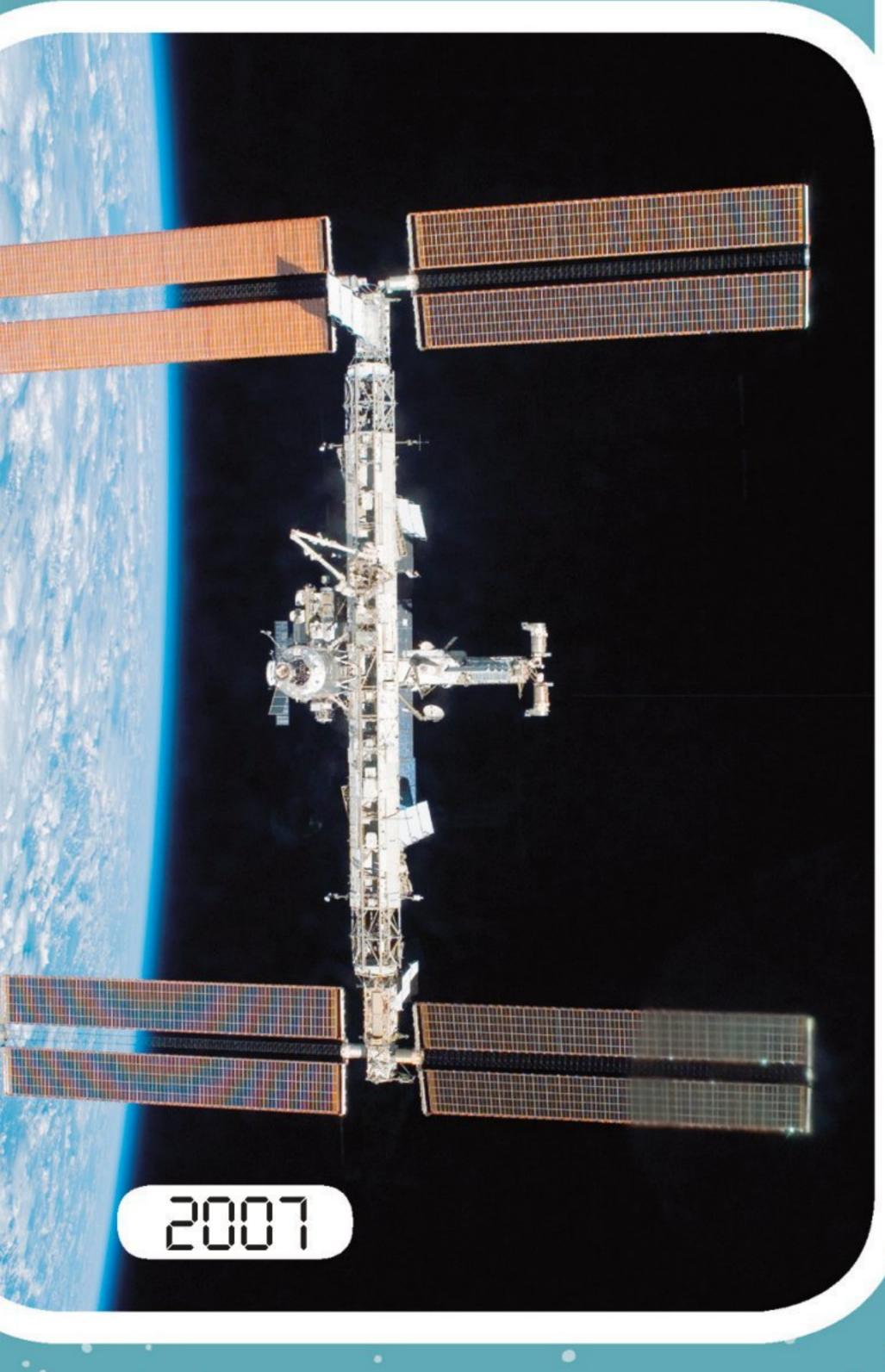
These collect sunlight, which
is converted into electricity.

In 1998, construction of the International Space Station (ISS) began. It was built piece by piece in orbit, and different parts were launched into space by both Russia and the United States. Astronauts and cosmonauts completed difficult space walks where they installed

modules, rewired systems, and made repairs to the outside of the ISS.

Space began to change from being a source of competition to a place where different countries could work together—even if they didn't get along with each other on Earth!

Building a space station

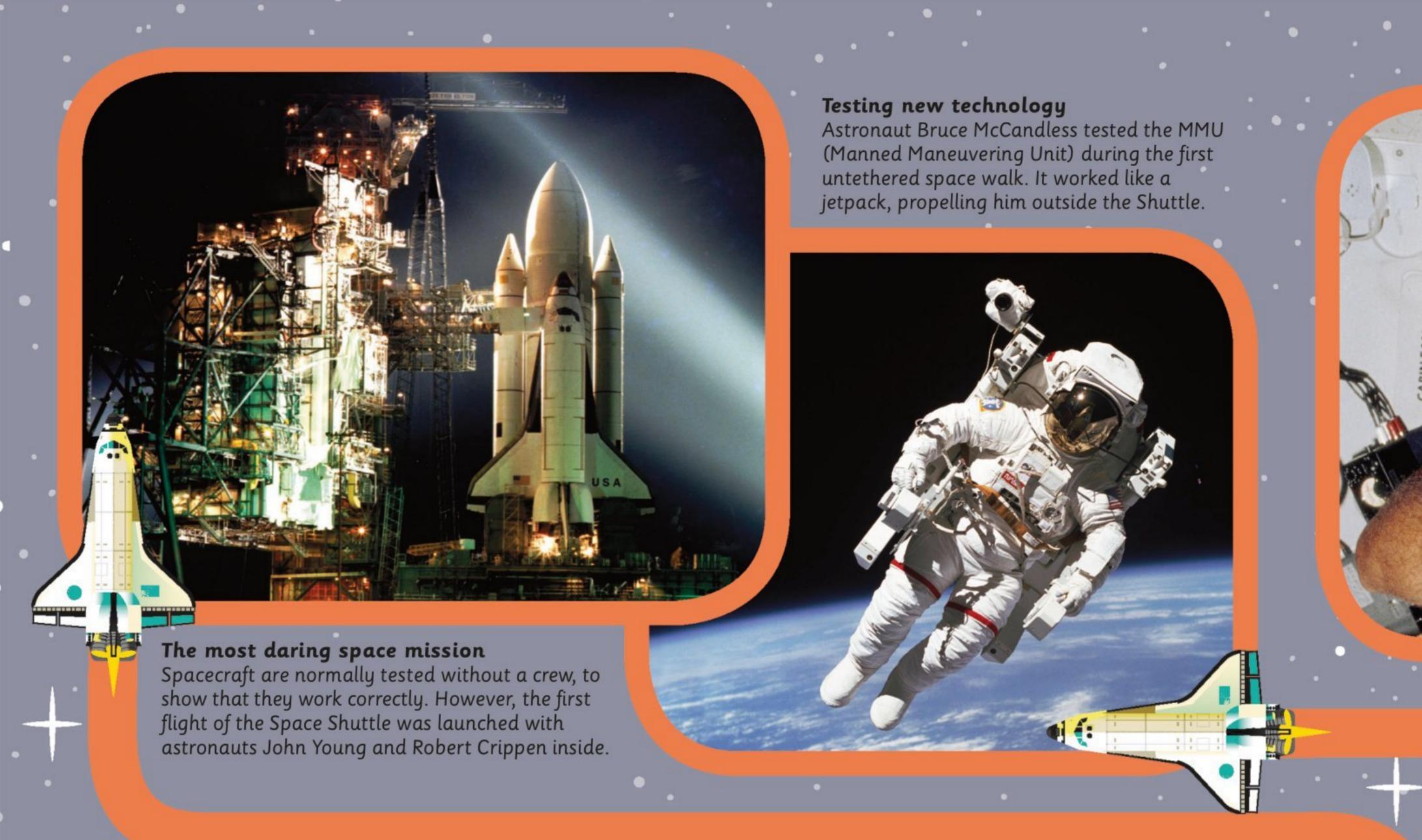




A new module

The space station is bigger than a football field! It is the biggest human-made object to orbit Earth.

A total of 15 countries worked on the project. The result was the world's largest outpost in space, orbiting at a height of around 250 miles (400 km) above the Earth. Since November 2, 2000, it has been occupied continually by people working in space.



Space workhorse

NASA produced a fleet of five reusable spacecraft: Columbia, Challenger, Discovery, Atlantis, and Endeavour. These were the Space Shuttles, and they took part in 135 missions over 30 years. The Shuttle program helped to build the ISS, launch and service the Hubble Space Telescope, and took 355 astronauts from across the globe into orbit.

One of the most complex pieces of machinery ever built, the Space

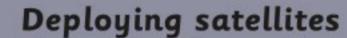
Shuttle did lots of work during its 30 years of service. It was used to conduct science experiments and launch satellites. It was also able to send other robotic spacecraft deeper into our Solar System to understand more about other planets. The Shuttle sent Magellan to Venus and Galileo to orbit Jupiter.

The lessons learned from those 135 missions have helped to lay the foundations for future space explorers.



Medical advances

Astronaut Norman Thagard may look like an alien here, but he was actually studying how the human body reacts to space travel.



The payload bay of the shuttle carried many satellites to space.
Astronauts could then make sure the satellites were placed in Earth's orbit correctly.



Space Shuttle tragedies

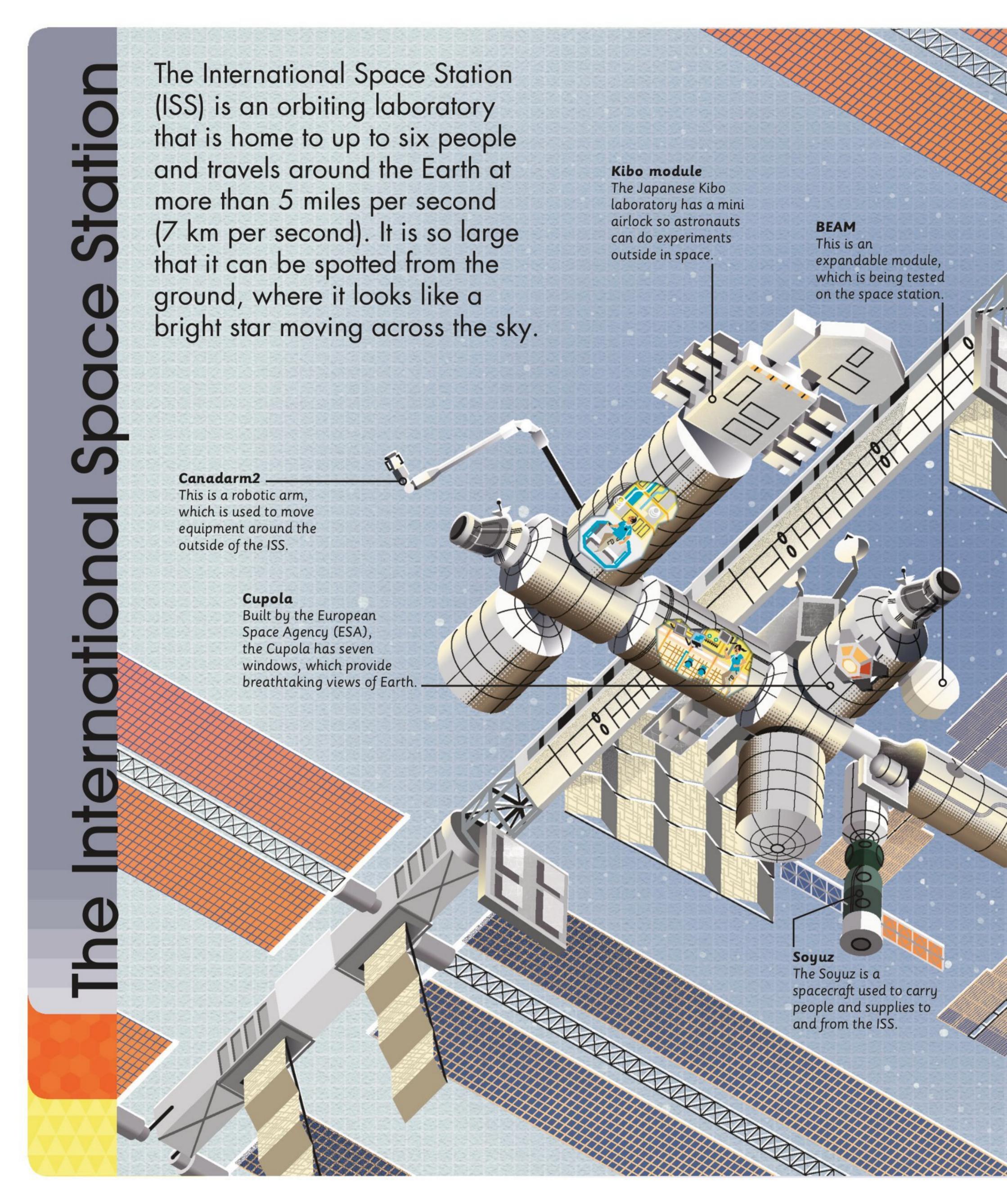
Unfortunately, traveling in a Space Shuttle was very dangerous. Two crews, with a total of 14 astronauts, lost their lives in separate disasters — Challenger in 1986 and Columbia in 2003.

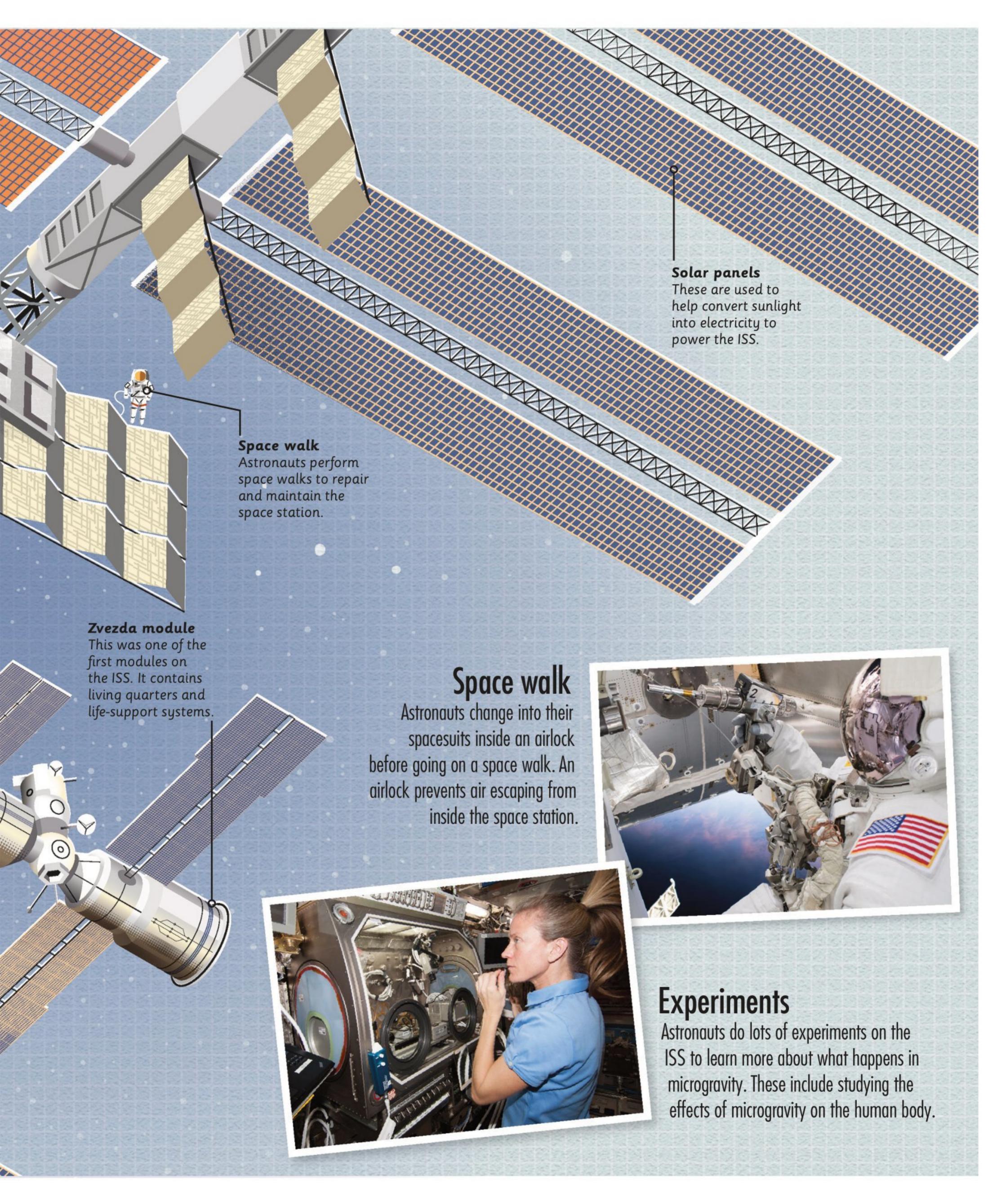


Challenger crew



Columbia crew







For astronauts aboard the ISS, space is their home. Most missions last several months and some astronauts stay for a year! Scientists have found ways of doing everyday tasks in the microgravity of space.

Staying clean

With no shower on the ISS, washing your hair is complicated. It involves using a pouch of water, shampoo you don't have to rinse out, a towel, and lots of patience, as the water can float away.

Catherine Coleman

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Samantha Cristoforetti The Party of the P

Astronauts have to do daily exercises in space to keep their muscles and bones in good shape. This is the treadmill used by astronauts on the space station—it comes with a harness that stops them from floating away when they're running.



TO DECK ON VALVE



TOYS A Russian tradition is to bring a cuddly toy on each space mission. The toy is a mascot for the mission, but it also indicates when the crew have reached weightlessness, as it begins to float around! 120

The Soyuz rocket

When the Space Shuttle program stopped in July 2011, the Russian Soyuz rocket became the only way for people to get to the International Space Station (ISS).

First introduced in 1966, the Soyuz has been launched more times than any other type of rocket. Different versions of the Soyuz rocket are also used on uncrewed flights to send supplies to the ISS and to launch satellites.

When a crewed Soyuz rocket launches, three people sit at the top of the rocket inside the Soyuz spacecraft. It's really small, so they have to squeeze





Squeezed into Soyuz

The only part of the Soyuz that returns to Earth is the Descent Module. There isn't much room inside!



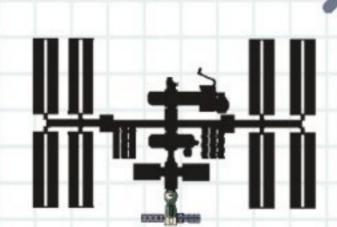
Landing

After reentry to Earth, a parachute is used to slow down the Soyuz's Descent Module, and engines fire to soften the landing.

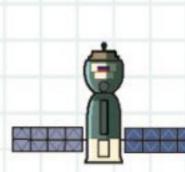
in tight. The Soyuz took its first crew to the ISS in November 2000. Since then, there has always been a Soyuz spacecraft stationed at the ISS, acting as a lifeboat back to Earth in case of an emergency.

Space travelers who launch on the Soyuz follow the traditions started by Yuri Gagarin. These include peeing on the back tire of the bus that takes them to the launch pad, and planting a tree before the mission.

Rocket launch



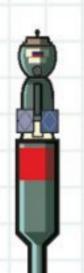
Within a matter of hours the Soyuz spacecraft docks with the ISS.



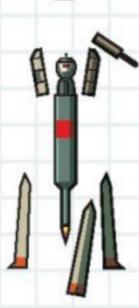
The Soyuz spacecraft unfolds its solar panels and begins its journey to dock with the ISS.



At around 124 miles (200 km), the third stage cuts off. The crew now experience weightlessness.



At 111 miles (180 km), the second stage separates and the third stage ignites to give the crew the last push they need to get to orbit.



After two minutes the first stage, the boosters, burn up and are ejected. The spacecraft's cover is dumped 30 seconds later.



The Soyuz rocket and crew launch from Baikonur, Kazakhstan.

The Soyuz rocket is very reliable. It has three parts, or stages, which are used to get the Soyuz spacecraft into orbit. It takes just nine minutes from liftoff for the crew to reach space!

Flying a spaceship

One of the most exciting things astronauts can do is fly a spaceship. At NASA, if you want to become a commander you must first become a pilot astronaut.

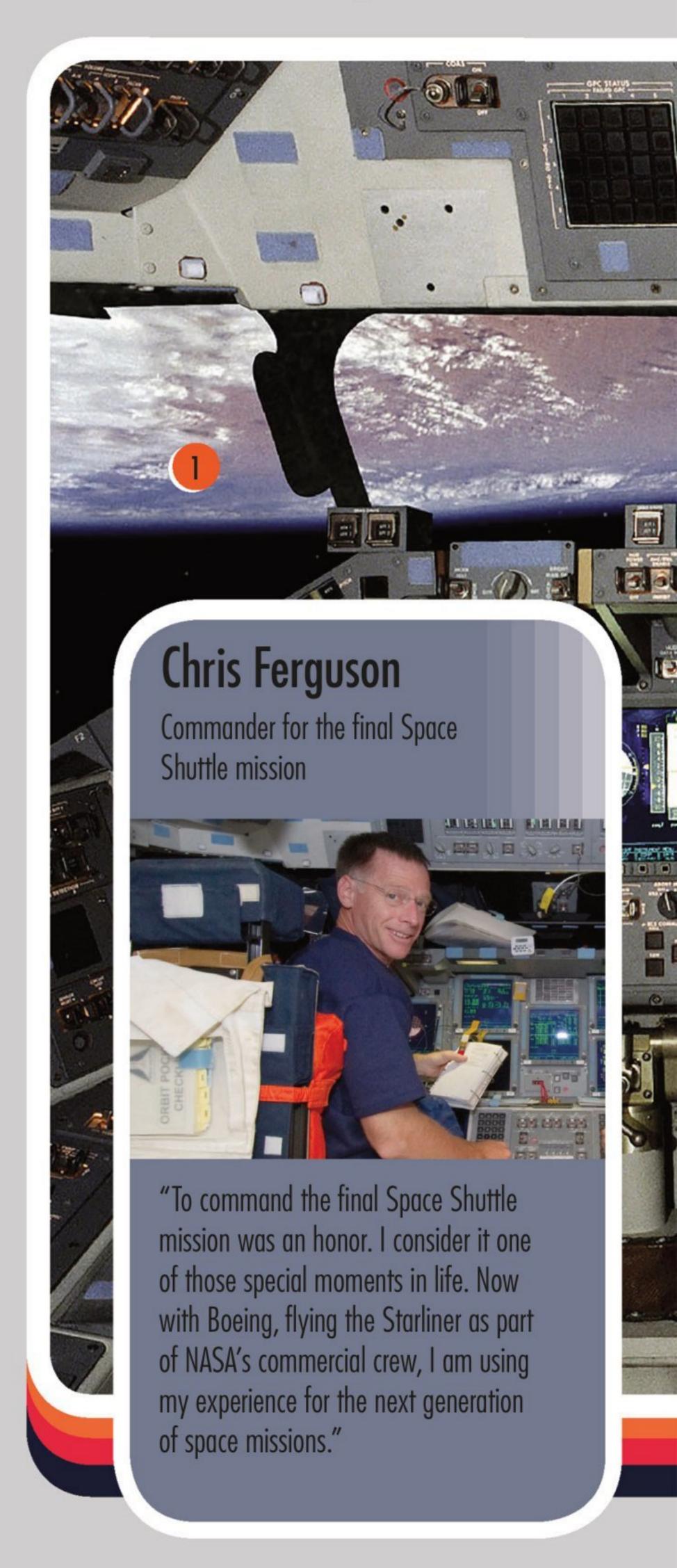
It is difficult to learn how to fly in space because of something called orbital mechanics. When you are in space, you have to slow down to go faster and speed up to slow down, which can be confusing!

Piloting the Space Shuttle involved three methods of flying. At launch astronauts flew a rocket, in space they flew a satellite, and when returning to Earth they flew an airplane.

Space Shuttle control panel

- Windows

 These were made of three layers of glass to protect the astronauts.
- Orbital readings
 The astronauts
 monitored the condition
 of their orbital engines
 and computers here.
- Plug panel
 Laptops were positioned
 here to assist in
 activities such as
 reading the flight plan.
- Switches
 Switches were
 used to help
 control the vehicle.
- Monitors
 These gave astronauts
 information about
 the spacecraft.





Being an astronaut doesn't always mean being in space. In fact, most of the time they work here on Earth. Astronauts have to train for a long time before going into space. They also help out on other missions, such as working in Mission Control as CAPCOM (capsule communicator).

One of the most exciting jobs astronauts do on Earth is live underwater. Nicknamed "aquanauts," they work undersea with professional divers, scientists, and engineers. This project is called NASA Extreme Environment Mission Operations, or NEEMO for short. Aquanauts spend up to four weeks living inside the undersea base Aquarius, which is located 62 ft (19 m) below the ocean surface, off the coast of Florida. NEEMO is hugely important. It helps NASA and



other space agencies prepare to explore different places in space.

Inside Aquarius, there are bunk beds for the aquanauts to sleep in, a table to eat at, and places to carry out experiments and research. Although still on Earth, this base is a completely alien environment for humans to be in. Here, aquanauts face some of the same challenges that people would encounter living on the moon, an asteroid, or another planet.

Aquanauts train for future space missions by going outside the base to collect "soil" samples and test "space walking" techniques. The underwater conditions are similar to weightlessness in space.

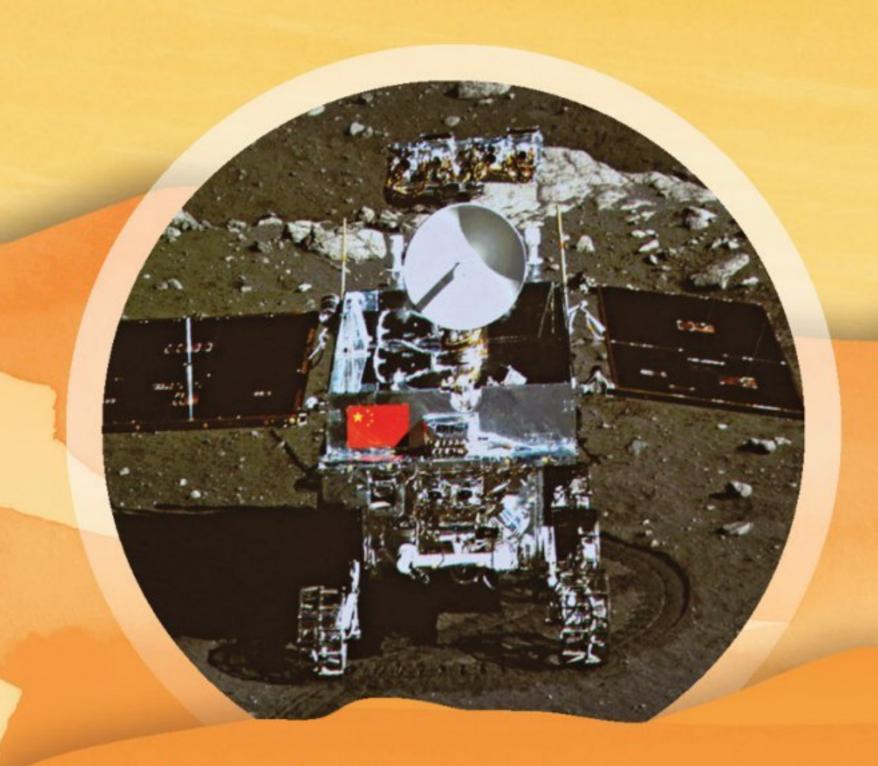


Visiting other worlds

Robotic spacecraft have been incredibly important in learning more about our solar system. While it might seem like we know a lot about space, we actually know very little—and the more we discover, the more questions we have.

As humans have focused on missions in Earth's orbit, these spacecraft, built by lots of different countries, have traveled billions of miles to explore deeper into space. They've revisited our moon and journeyed to comets and the gas giants. Along the way they've discovered possible liquid oceans on other moons and listened to the eerie sounds of Jupiter's powerful atmosphere.

They are our eyes and ears into the universe. Traveling to places humans cannot yet visit, they are continually rewriting our understanding of space.



Jade Rabbit on the moon

China's Yuto ("Jade Rabbit") rover landed on the moon in 2013. Yuto was controlled from Earth and sent back incredible color photos.



Mickey Mouse on Mercury

Mickey Mouse was spotted on the planet Mercury — or rather, a group of craters that look like him! They were discovered by NASA's Messenger spacecraft.



Craters on Venus

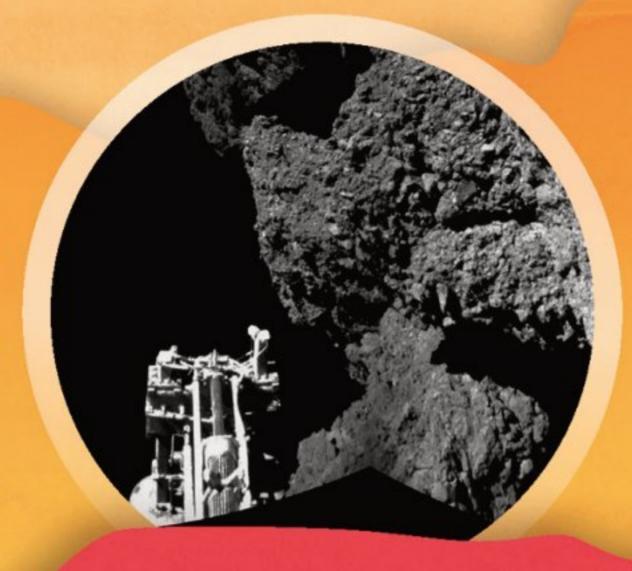
This crater was caused by a meteorite hitting the surface of Venus. Data from two Soviet Venera missions and NASA's Magellan mission were used to create this image.

Titan's surface

Saturn's moon Titan has an atmosphere and is a little like a young Earth. When the European Huygens spacecraft landed here, it discovered a world with an orange sky and a sticky, claylike surface.

Philae lander

The Philae lander traveled across our solar system with the European Space Agency's (ESA) Rosetta spacecraft, before landing on the surface of a comet in 2014!



LEGO® Minifigures aboard Juno

LEGO® Minifigures have been to Jupiter! Minifigures of the god Jupiter, his wife Juno, and scientist Galileo Galilei traveled to the giant planet in NASA's Juno spacecraft.





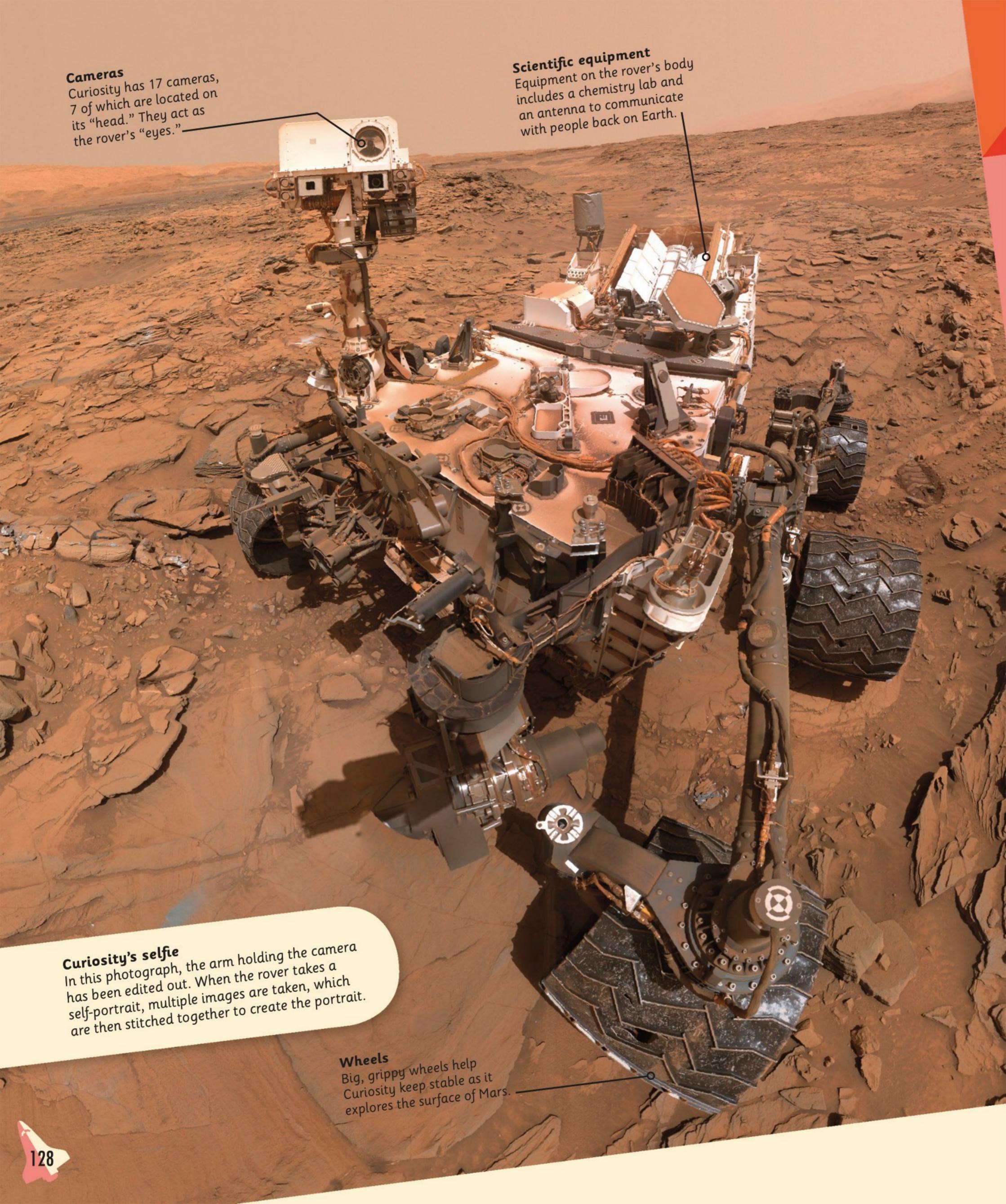
Jupiter's south pole

Jupiter's south pole is beautiful, but you wouldn't want to live there. The oval shapes are powerful cyclones up to 620 miles (1,000 km) wide. They were discovered by NASA's Juno spacecraft.



Saturn's rings

Imagine diving through Saturn's rings. That's exactly what NASA's Cassini spacecraft did! The rings are made mostly of lumps of ice, ranging in size from a grain of sand to a mountain.



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One of the most exciting places robotic spacecraft have visited is Mars. They first started exploring the Red Planet in the 1970s, when NASA sent its two Viking probes. They performed "soft landings"—landings that don't damage the spacecraft—on the Martian surface and took color photographs to show us what Mars looks like.

Today Mars is a planet occupied by robots. Controlled from Earth, they drive around taking photographs and doing experiments. With the help of spacecraft orbiting around the planet, they are looking for water, past signs of life, and perhaps even evidence of simple life-forms that might still exist today. One of the most famous robot residents is NASA's Curiosity rover, which has roamed the planet since 2012, studying Martian soil and rock samples.

Robots will continue to explore Mars—until we're ready to send people there instead...

Mars Atmosphere and Volatile Evolution (MAVEN)

NASA's MAVEN spacecraft orbits around Mars. Launched in 2013, its aim is to find out more about the history of Mars's atmosphere and climate. It is also trying to discover whether the planet can support life. This image shows an artist's impression of the spacecraft in orbit.

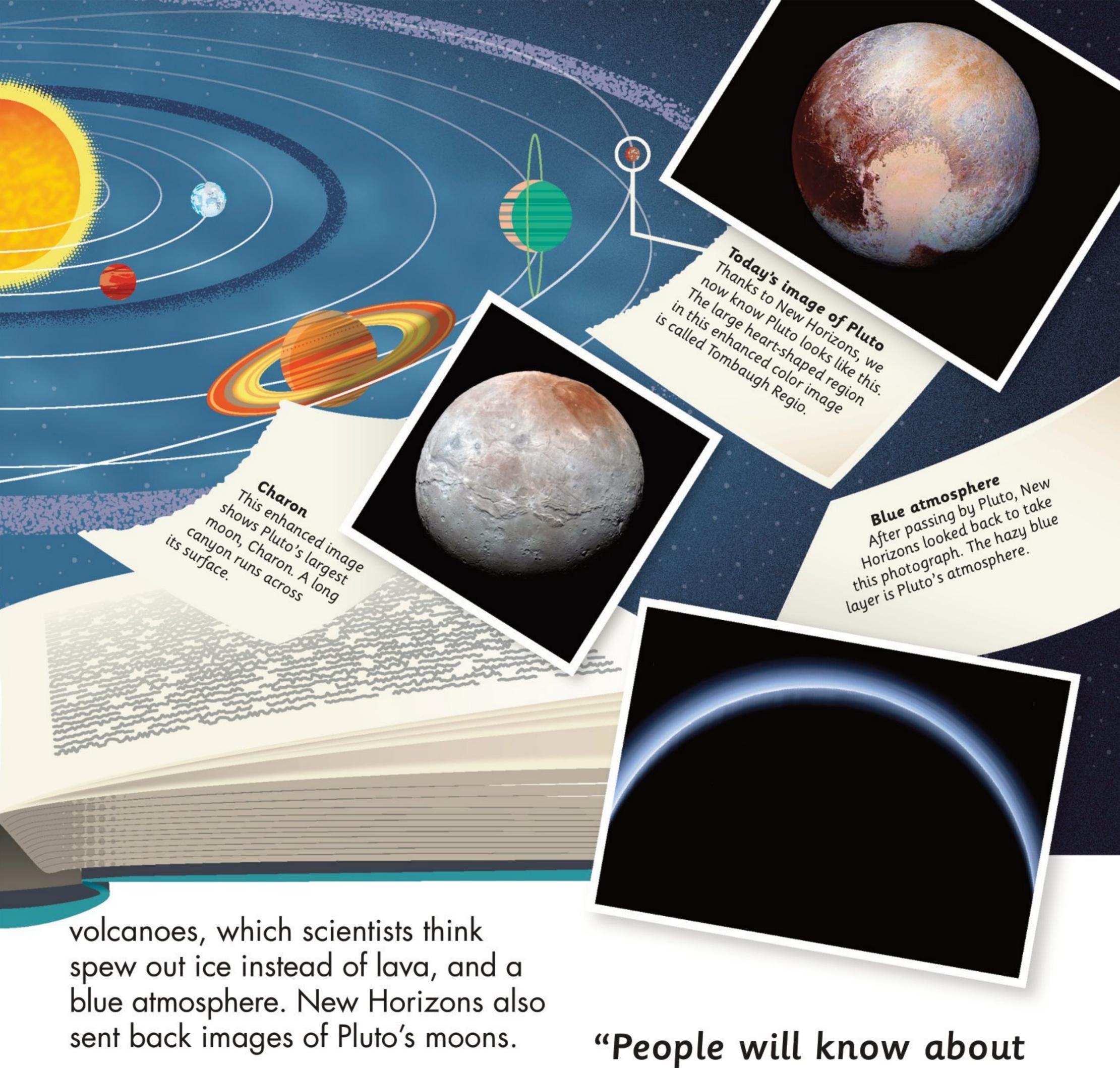




The New Horizons mission to Pluto and the Kuiper Belt is showing us worlds beyond our imagination. It's the story of an incredible journey to the edge of our solar system.

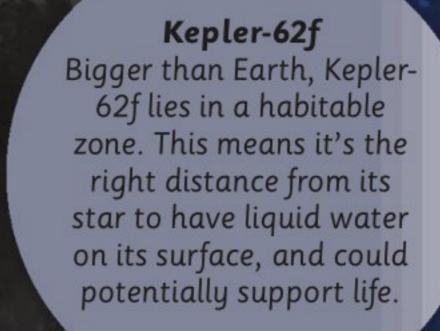
When the New Horizons spacecraft was launched in 2006, Pluto was still known as a planet. A few months later, it was reclassified as a dwarf

planet. New Horizons reached Pluto—its first destination—in 2015, after traveling 3 billion miles (4.8 billion km) from Earth. Pluto had once been dismissed as a "boring lump of rock," but the spacecraft discovered an amazing world. It had a gigantic heart-shaped region of frozen nitrogen, now named Tombaugh Regio. There were



The New Horizons spacecraft is still exploring the Kuiper Belt. It's traveling to the farthest reaches of our solar system, and the story of what we will find is only just beginning...

"People will know about this mission for centuries to come."—Alan Stern, Principal Investigator of the New Horizons mission



planet hunting

We are living in an age of discovery about space. Recently, we've learned that when you look up at the night sky, almost every star you can see has one or more planets orbiting around it. Planets that orbit around other stars are called exoplanets. For a long time, people wondered whether such planets existed, but it took until the 1990s for the first confirmed detection.

We now also know that many stars other than our sun have

multiple
planets—the
universe is teeming
with solar systems. We have
even found planets that don't
orbit around a star. Known as
rogue planets, they wander the
universe alone.

Some exoplanets are gas giants, even more gigantic than Jupiter. There are water worlds and even a planet made mostly of diamond! Just imagine what else could be out there.







*

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Space was once a tale of two powerful nations: the Soviet Union and the United States. Today, it is a tale of nearly every person on Earth.

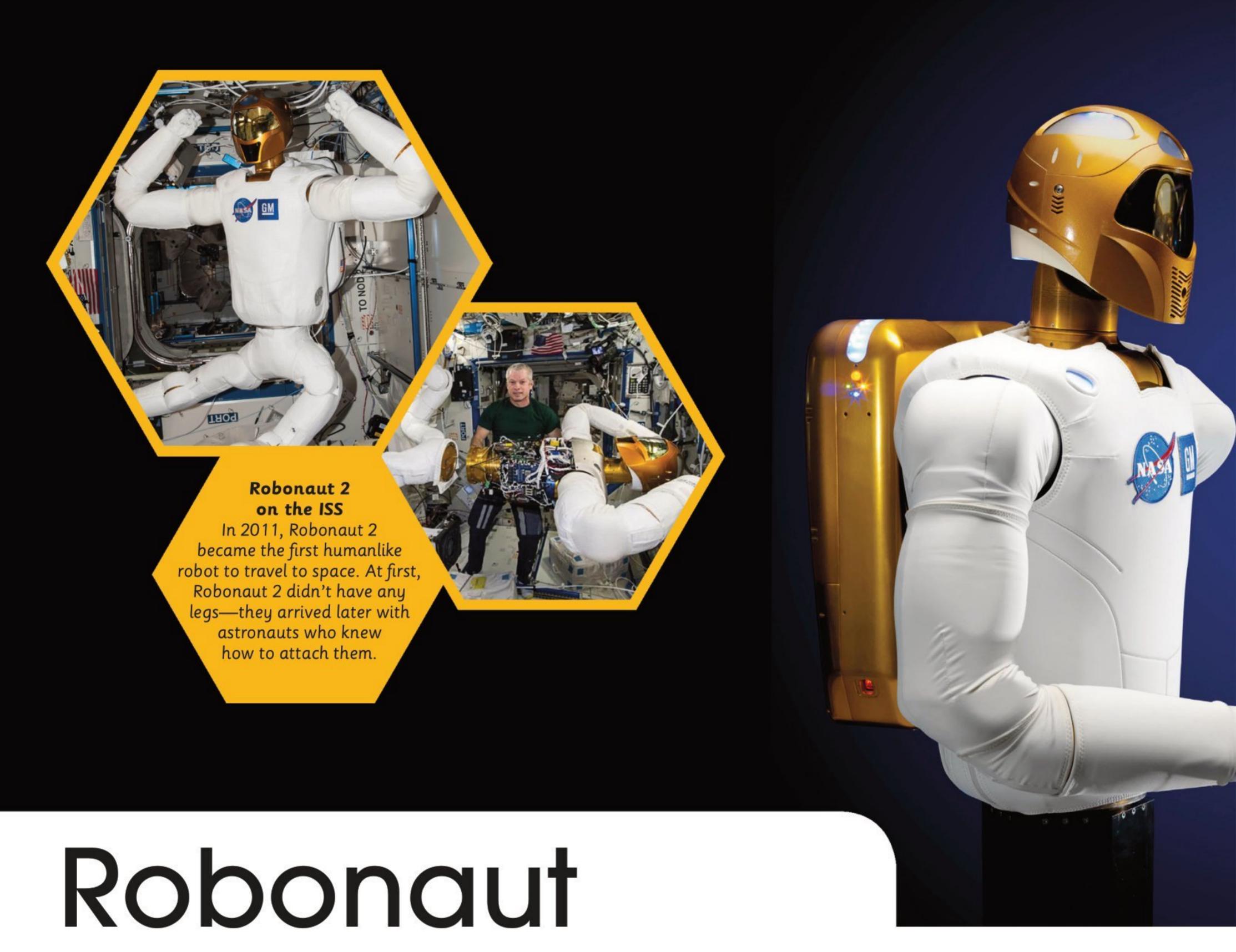
Space exploration is now global, and the number of countries involved is growing every year. Going to space is no longer just about government-owned space agencies such as NASA—commercial companies, who plan to make money from space travel, and individuals are now involved.

Our journey into space is not too different from how pioneers like Christopher Columbus explored the Earth. He sailed to the Americas in 1492 and inspired more Europeans to cross the oceans. Similarly, space race pioneers, such as Yuri Gagarin and Neil Armstrong, inspired us to travel to space.

These space heroes laid the foundations for countries, companies, and individuals to head into orbit.







Ever wondered what it would feel like to shake hands with a robot? Well, astronauts already know.

Meet Robonaut. Robonaut is a robotic helper designed and built by NASA. A version of Robonaut, called Robonaut 2, even lived in space, aboard the International Space Station. Robonaut is a humanoid robot, as it was designed

with similar features to humans.
Robonauts can help astronauts by doing time-consuming chores, repetitive tasks (they don't get bored), and helping with dangerous jobs.

As we continue to explore deeper into space, robotic crew members are going to become very important. Versions of Robonaut could be sent to new places before humans—to



set up tools, living quarters, and experiments so that everything is ready when humans arrive. Robonauts could also be adapted to have wheels instead of feet so that they can move around quickly.

Future astronauts could even wear robotic clothing, which would give them robotlike abilities.
NASA has already developed

robotic gloves, which could help space-walking astronauts, and in the future, astronauts could wear entire robotic suits—known as exoskeletons. These suits could give the wearer improved mobility and strength, and they could help people who are unable to walk to move again. In fact, all of the robotics being developed for space could improve life for people on Earth.

Introducing the new class of rockets. These aren't just mega-rockets, these are super mega-rockets, part of a new generation with the potential to help humans have even greater adventures in space.

New Glenn 3-stage

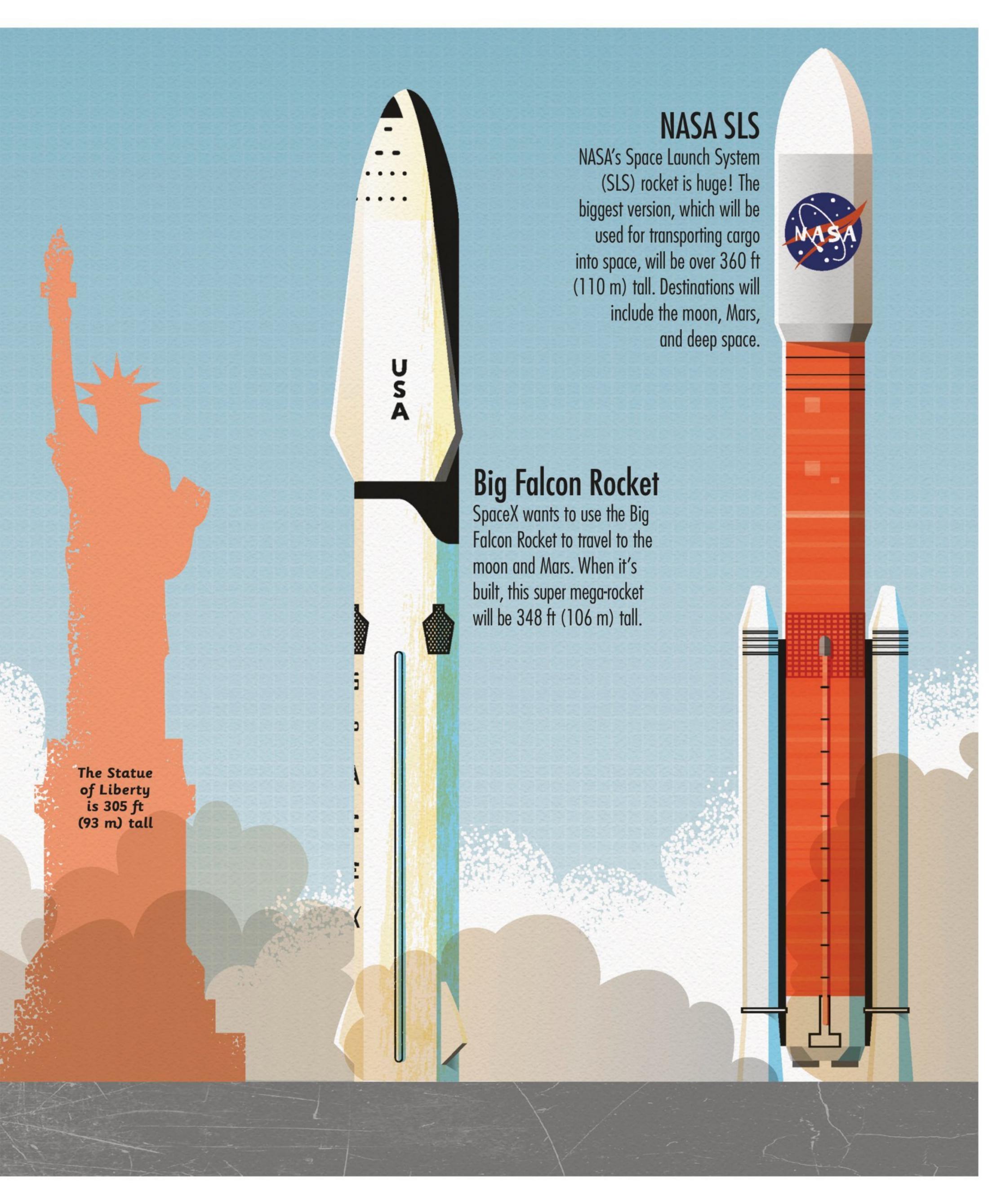
Blue Origin's New Glenn 3-stage rocket is 326 ft (99 m) tall. It will be used by Blue Origin to help more people access space.

Delta IV Heavy

Manufactured by United Launch Alliance, the Delta IV Heavy rocket's achievements include launching the Parker Solar Probe to "touch" the sun in 2018. At 236 ft (72 m) tall, this super mega-rocket is reliable and powerful.

Falcon Heavy

Standing at a height of 230 ft (70 m) is SpaceX's Falcon Heavy rocket. It launched a car into space in 2018, and its boosters, which give the rocket extra power at launch, can land back on Earth to be reused.



Landing back on Earth

When you travel by airplane, it isn't thrown away after just one flight. However, for a long time, that's exactly what happened with space rockets. Now, new rockets are being developed that can launch satellites and spacecraft to orbit and then land back on Earth on either a landing pad or a barge in the ocean. For some missions, landing on a barge at sea is necessary, as the rockets don't have enough fuel left to make it back to a landing pad.

One of the biggest obstacles facing future space exploration is cost. It is very expensive

Reusable rocket

While it might look like this is a rocket taking off, it's actually the first stage of SpaceX's Falcon 9 rocket landing back on Earth.

to launch rockets that send people and experiments to space.

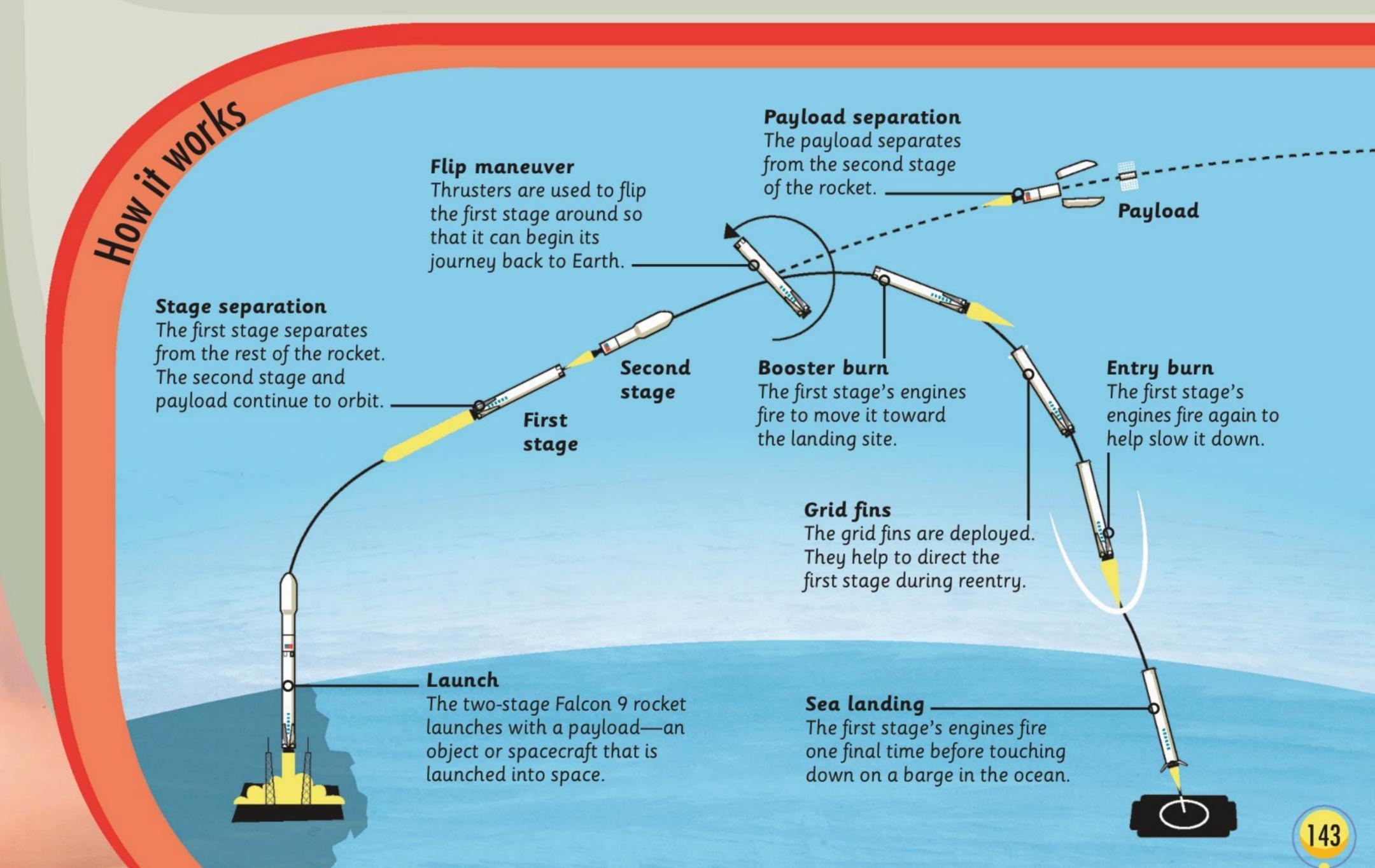
While the Space Shuttle fleet was reusable, it cost a lot to operate—an average of \$450 million per mission.

Companies like SpaceX and Blue Origin are creating reusable rockets that will make it easier and cheaper to access space. This is great news for people who want to go to space, or have ideas for new experiments that could be done in orbit.



Perfect landing

One of the companies perfecting landing rockets back on Earth is SpaceX. The first stage of their Falcon 9 rocket has to slow down from speeds of 1.5 miles per second (2.4 km per second) to ensure a safe landing.



Musk vs.

Elon Musk and Jeff Bezos are two of the richest people on the planet. They are both passionate about space travel and are using their wealth to change the way we explore space.

Elon Musk has a company called SpaceX. He founded it because he thinks that a future in which people are exploring the stars is much more exciting than one in which they are not. SpaceX works with NASA to send supplies, and also astronauts, in its Dragon space capsules to the International Space Station (ISS).

SpaceX car

In 2018, Elon Musk launched his car into space! Strapped into the driver's seat was a dummy in a spacesuit, nicknamed "Starman." The car was a test load for the first flight of SpaceX's Falcon Heavy rocket.



However, Elon's ultimate goal is Mars. He wants to send humans there and eventually colonize the Red Planet.

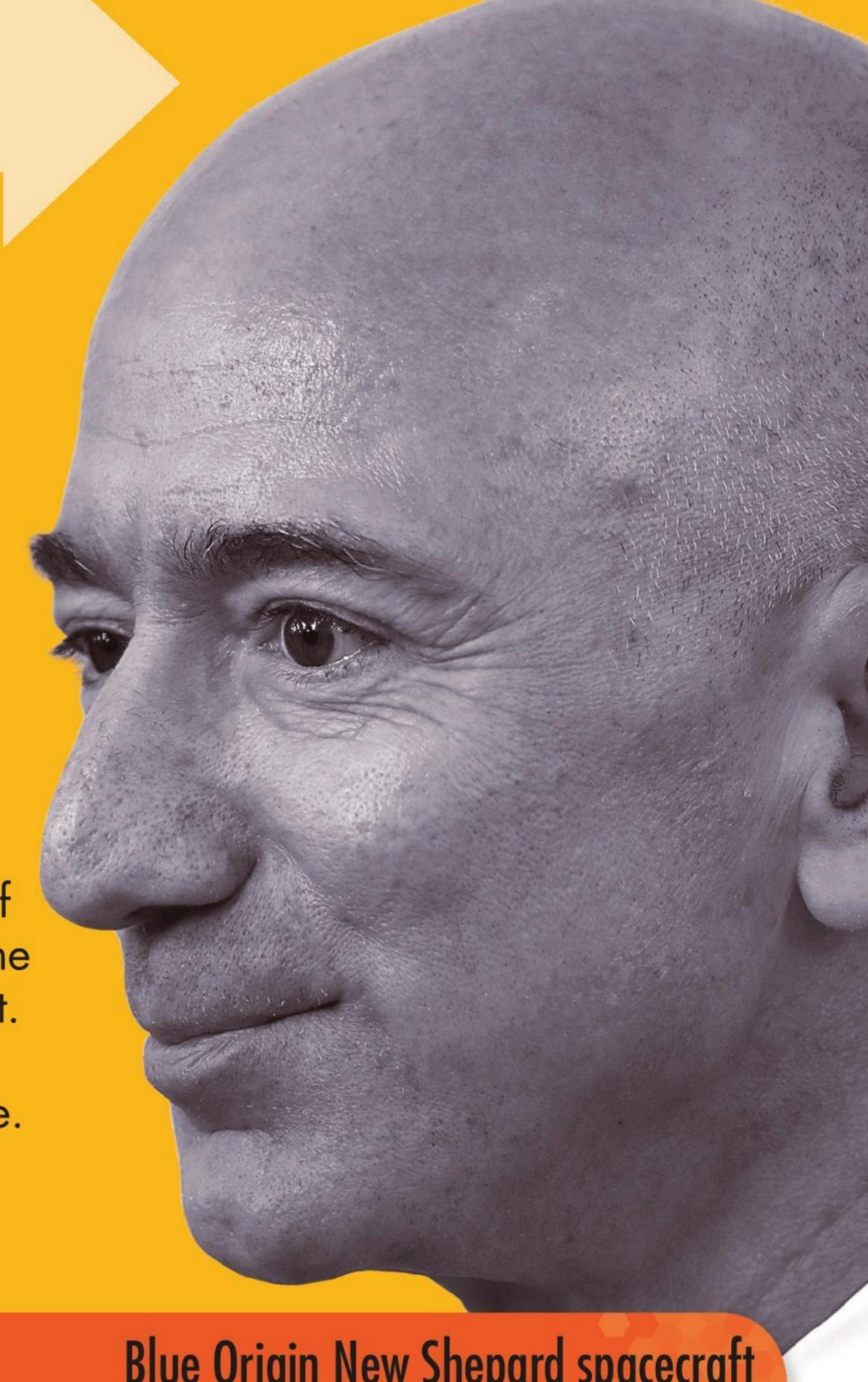
Bezos

Jeff Bezos's motto is gradatim ferociter, which is Latin for "step by step, ferociously." He uses this approach for his space company, called Blue Origin, step by step working to improve technology. The aim is to make it cheaper to go to space—for astronauts and tourists, too.

Jeff also wants to move factories off the Earth. They'd be powered by the sun and wouldn't pollute our planet. His vision is to have millions of people living and working in space.

Elon and Jeff share something

in common—they had ideas that at the time seemed impossible, but they turned them into reality. Together they are shaping a new space age.



Blue Origin New Shepard spacecraft



Named after the astronaut Alan Shepard — the first American to go to space — New Shepard is a reusable launch vehicle. The rocket takes off and lands vertically, and it has been designed to take tourists on space trips.

Space junk

Everywhere humans go, we seem to leave trash in our wake, and space is no different. There are more than 500,000 pieces of junk, which are larger than a marble, orbiting around our planet. There are bits of used rockets, broken satellite parts, and even tools that astronauts may have lost during spacewalks.

One of the biggest problems is that as the number of objects orbiting Earth increases, so do the chances of a collision. When two pieces of junk collide, even more junk is

created when the pieces break up and become smaller.

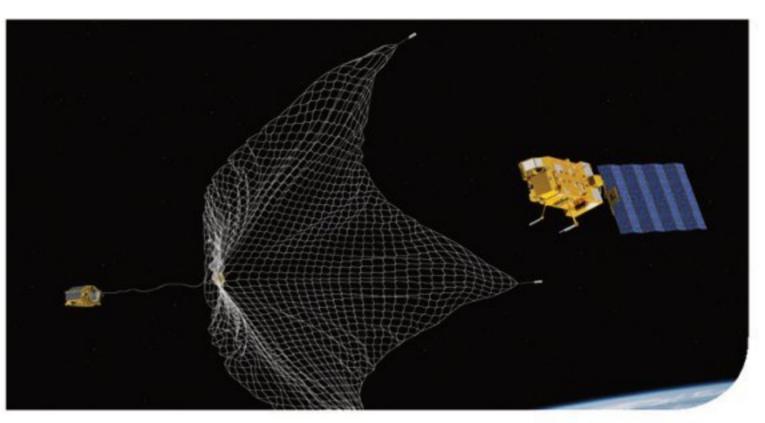
Even small pieces of junk can cause problems. Hurtling around Earth at speeds of up to 17,500 mph (28,000 kph), small pieces of space junk have the potential to cause serious damage to the ISS or the many satellites people on Earth rely on.

As we continue to go to space, one of the biggest questions we need to answer is "How do we clean up all of this mess?" If we don't, we could put future missions in danger.

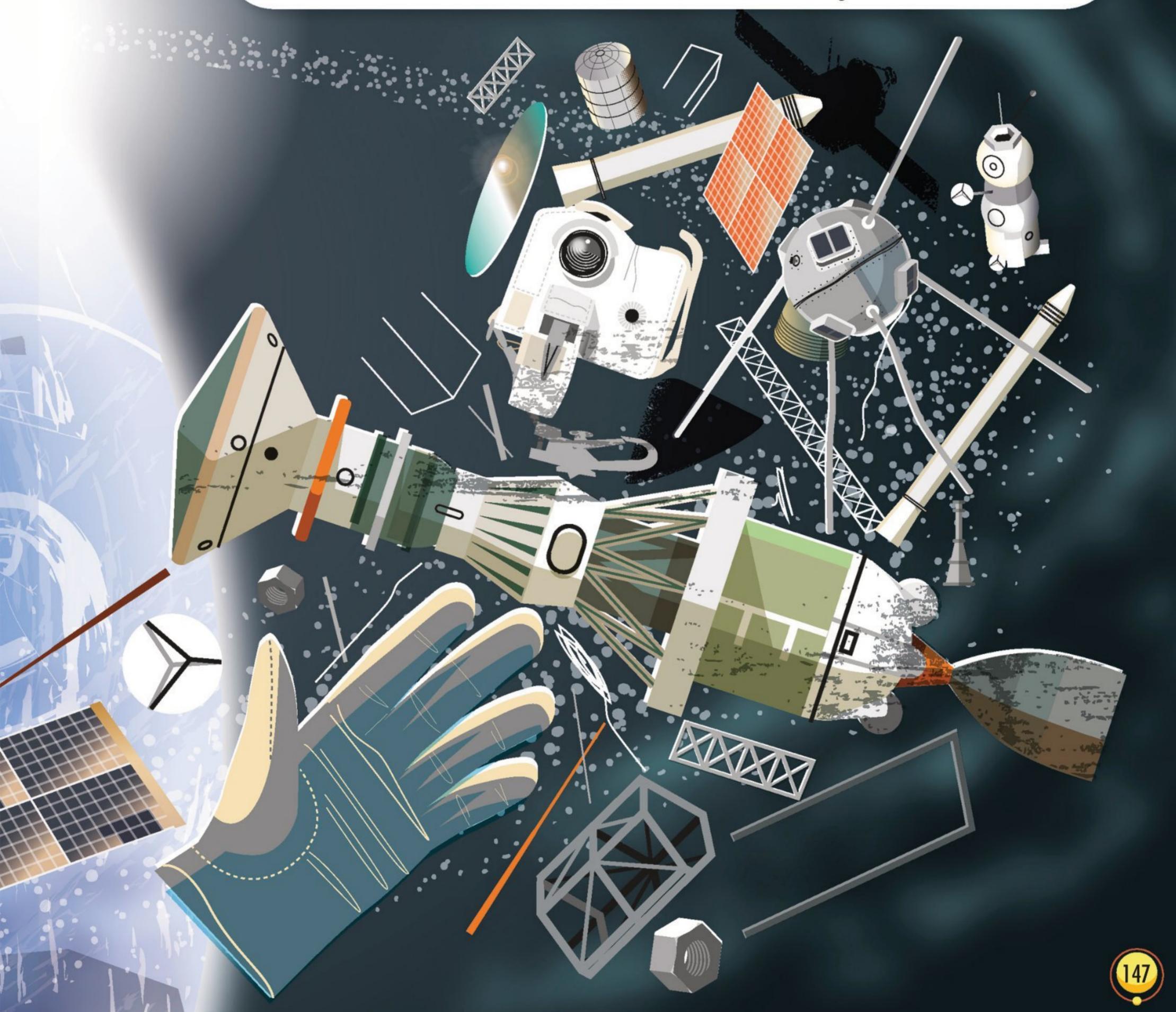


How to clean up space

At the end of their mission, modern satellites are designed to burn up in Earth's atmosphere or move out of the way of active satellites. However, older satellites remain in space. One idea for cleaning up these satellites is to use a net to capture them. Another method is to grab the old satellites with harpoons and reel them in. They would be removed from orbit by being sent to burn up in Earth's atmosphere.



Catching a satellite in a net



A new space nation

There are now three nations that can launch people into space: the United States, Russia, and China. Ancient Chinese legends used to talk about people traveling to space, and China has a long history with rocketry and astronomy. At the start of the 21st century, China finally sent a person into space.

In China, an astronaut is known as a taikonaut [tie-ko-naut].

China's Long March 2F rocket prepares for launch in 2011





In 2003, Yang Liwei
became the first
person to be sent to
space by the Chinese
space program.
He launched into
space aboard the
Shenzhou 5 spacecraft.



Liu Yang
The first Chinese
woman to travel to
space was Liu Yang.
She orbited the Earth
in 2012 as part of the
crew of Shenzhou 9.

Taikonauts travel to space in a spacecraft called the Shenzhou, which means "divine vessel." Just like in the United States and Russia, the Chinese have different types of rockets for different missions.

As well as sending people and satellites into space, the China National Space Administration (CNSA) set its sights on the moon. It sent an uncrewed spacecraft called Chang'e 1 to orbit the moon in 2007, and was able to explore the

surface of the moon in 2013, using a robotic spacecraft called Yutu.

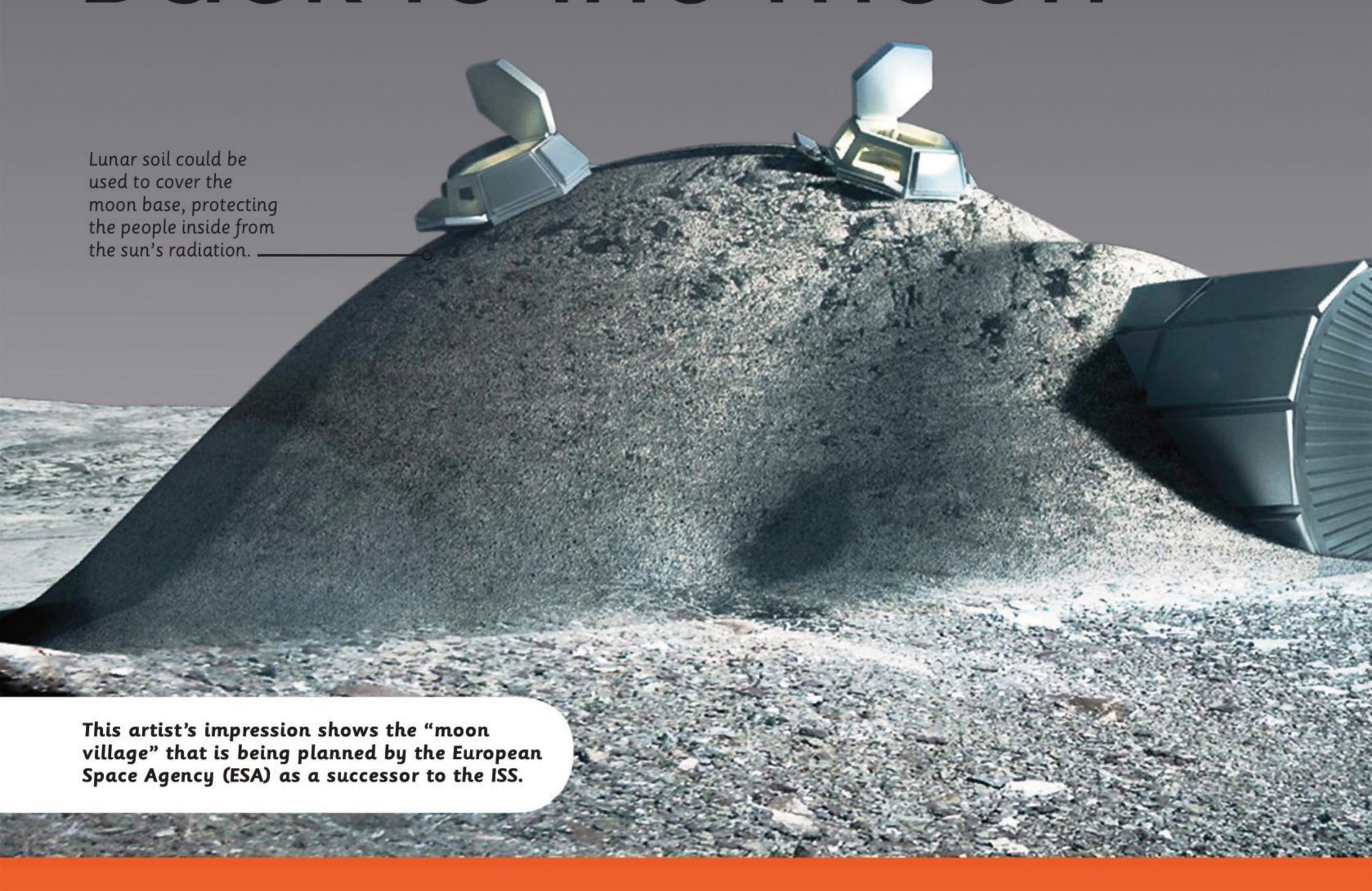
In the future, China plans to send more spacecraft to explore the moon, including the far side. It also wants to send spacecraft to explore Mars and the outer gas planets in our solar system.

Tiangong-1 space station



Tiangong-1 was China's first space station, which orbited the Earth from 2011 to 2018. The size of a school bus, it was used to host two different crews of taikonauts.

Back to the moon



One day, when you look up at the moon, there will be people living and working there. When NASA's Apollo missions ended in 1972, nobody believed that we wouldn't go back for so long. Instead, we made huge steps learning how to live in space—in space stations orbiting around the Earth. The knowledge gained from this will help us put people—men, and for the first time,

women—back on the moon.
However, this time it won't just be for short visits. We'll build a permanent base there. The moon is only three days away from Earth, so it can be used to test the technology we need to send people to other planets.

Space agencies and private companies are already exploring how to make this happen.





Moon Museum

The Apollo landing sites, with all the objects and signs of activity left by the astronauts, still remain on the moon. With no weather on the moon, the astronauts' footsteps will last for thousands of years. Future moon explorers will be able to visit these sites. They could become an "off-world" museum, honoring the groundbreaking achievements of the Apollo missions.

How to move to space

The distance from the ground on Earth to space is around 62 miles (100 km). Space isn't that far away, but there are lots of challenges to overcome if you want to move there.

On Earth, we have everything we need to survive, such as air to breathe and food to eat. If you are sick you can visit a doctor, if you're thirsty you can turn on a faucet to get water, and Earth's atmosphere protects us from harmful radiation from space.

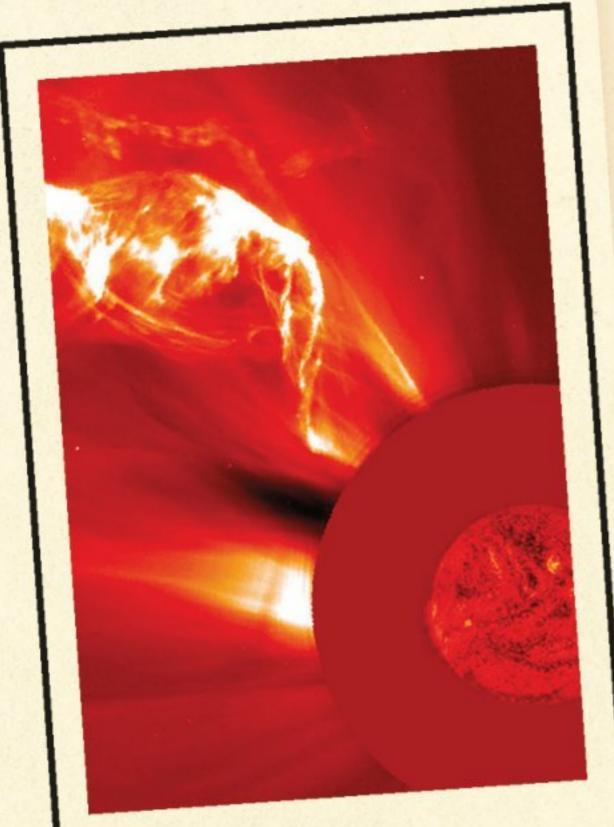
On the International Space Station (ISS), astronauts are supported by supplies sent from Earth—including air, water, fuel, and food. In an emergency, they can travel back to Earth very quickly. However, in order to go deeper into space, future explorers will need to be able to support themselves.



Food and water
We won't be able to
take much food with us
when we explore space,
so we need to learn
how to grow plants in
microgravity. As for
water—astronauts
already recycle their
urine to drink on the ISS!

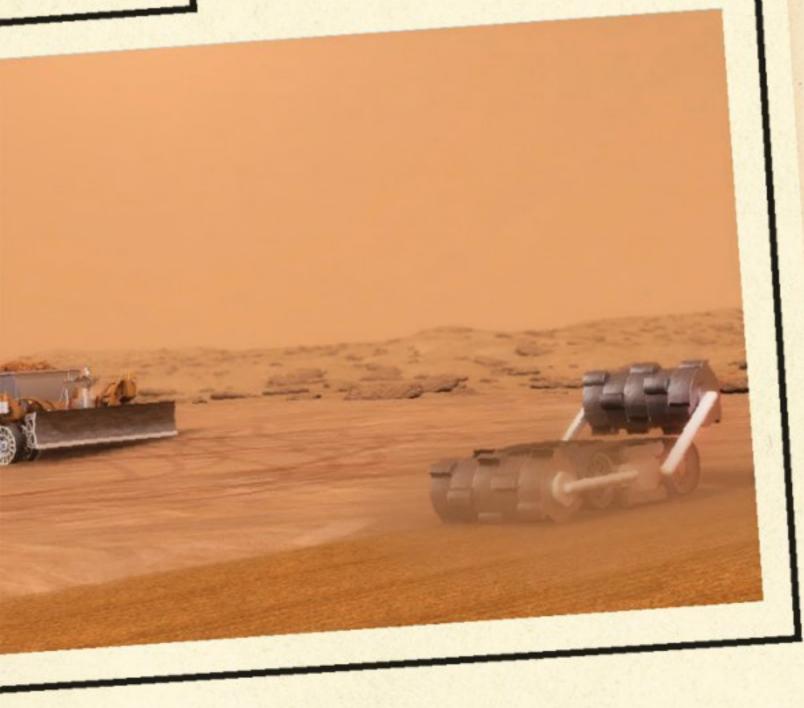
Staying healthy
Astronauts will
need to take medical
supplies with them in
case of emergencies
far away from Earth.
Some people will also
need to be trained to
perform operations
in space, should an
accident happen.





Protection
from radiation
Charged particles from
the sun pose a radiation
threat to space travelers.
One of the best ways to
protect astronauts is to
put a layer of water
around the spacecraft.
Plastic can be used for
added protection.

Learning to live
off the land
On Earth we have
learned to use the
resources available
to us, like water and
soil. We will need
to do this on the moon
and Mars to survive.

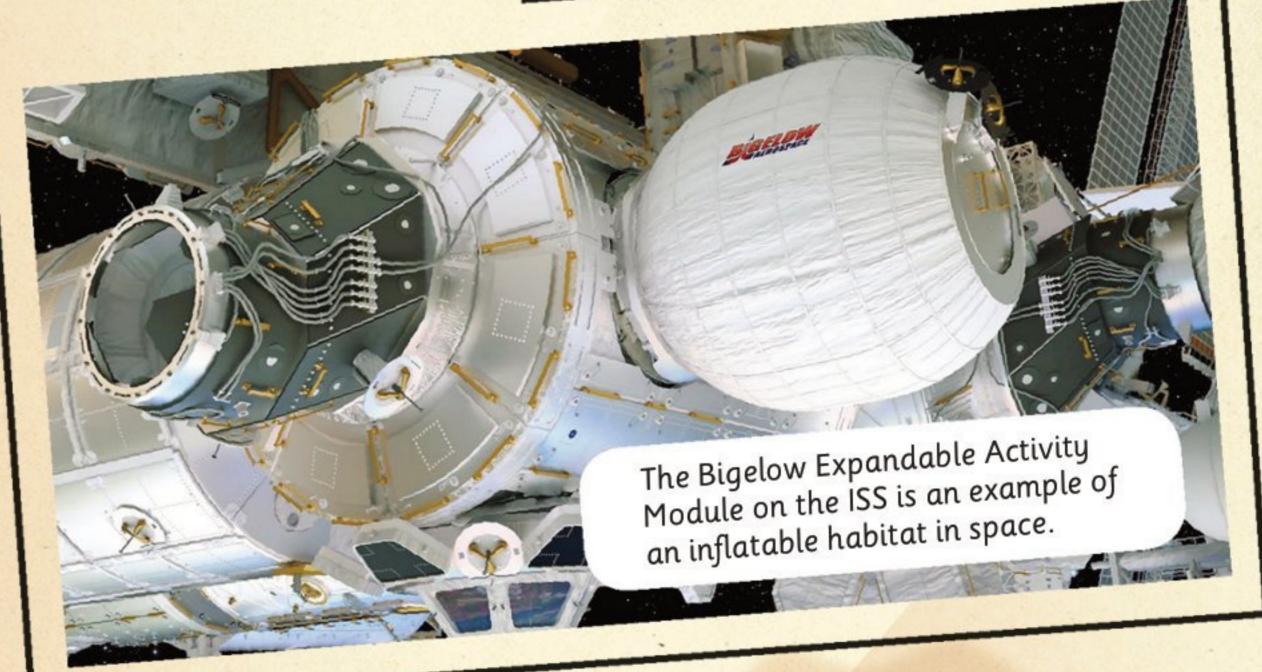


On a long space mission, it will just be you and your crew completely alone. In order to understand how isolation affects humans, astronauts practice on Earth in extreme environments, such as in Antarctica.



Homes in space
Future astronauts
could live in pop-up
homes, which can
be expanded in space.
These homes take
up a small amount
of room on a space
rocket, meaning
they are cheaper to
launch and you can
take more with you.

Fully reusable rockets will reduce the cost and difficulty of exploring further into space. In the future there could be a team of people stationed in Earth's orbit, supporting deep-space missions.



WANTED: Asteroid Asteroids are lumps of rock, metal, dust, and ice. They are leftovers from when the solar system formed, around Asteroid 4.5 billion years ago. miners Mining spacecraft Asteroid-mining spacecraft could be used to study asteroids to see which ones are the best to mine.



For the past few years people have been trying to work out how they could mine for precious materials in space. Between the planets Mars and Jupiter lies the asteroid belt, where most of the asteroids in our solar system live. This is a place with more than a million asteroids, some of which contain rare metals such as platinum and gold. Whoever succeeds in mining asteroids would become very wealthy.

However, becoming wealthy is not the main reason that people want to mine in space. Some of the asteroids, as well as the moon, contain frozen water ice. Water is made up of the elements hydrogen and oxygen—things that are very important for space explorers, as they can be converted into rocket fuel.

In the future, asteroids and the moon could become a bit like gas stations in space—allowing spacecraft to refuel before heading deeper into our solar system.

OSIRIS-Rex



In 2017, NASA launched the OSIRIS-Rex spacecraft. Its mission is to visit an asteroid called Bennu, bring back a sample from the surface, and help scientists understand more about what asteroids are made of. The mission is also helping to develop important technologies for asteroid exploration, which will help future space miners.

Vacations in space

Since the beginning of the space race in the 1950s, people have dreamed of going on vacation to space. Today, that dream is almost a reality, and some tourists have already gone on trips to the International Space Station (ISS).

In the near future, many more of us will get to go to space. Travel companies will take people on trips to space that last a few hours. The space tourists will be able to see the Earth from afar, and experience what it is like to feel weightless. However, the first trips will be extremely expensive.

What is happening now is not too different from when airplanes first started taking paying customers. In the beginning the trips cost a lot of money, but as airplane technology evolved and flights became cheaper, more people were able to take to the skies. The same will be true for space. One day in the future, people may be able to board a spacecraft to go on a vacation to another planet.

Space holidays



Destination:

In development



Float up to the edge of space with World View. Enjoy fine dining and beautiful views from your balloon capsule, before gliding back to Earth.

Future destinations



3,988 reviews

Earth isn't the only planet where you can experience auroras. Jupiter also has these naturally occurring light displays and they are the greatest in the solar system.

Check in:

Check out:



Blue Origin
Launch in the New Shepard capsule to more than 62 miles (100 km) above Earth. Experience 15 minutes of weightlessness before the capsule parachutes back down to Earth.



Virgin Galactic

Spend time in space aboard SpaceShipTwo. The spacecraft will be carried into the air by the WhiteKnightTwo aircraft, before being released midair and firing its rockets to get to space.



The first tourist in space was named Dennis Tito. In 2001, he paid \$20 million for an eight-day trip to the ISS.



Titan

2,895 reviews

Fly to Saturn's largest moon, Titan, and experience how the Earth may have looked before life as we know it began.



Kepler-186f

2,654 reviews

Experience Kepler-186f — a planet outside of our solar system that may have red grass!

As humans explore deeper into our solar system and arrive at new moons or planets, they could use 3-D printers to create everything they need using just the materials around them.

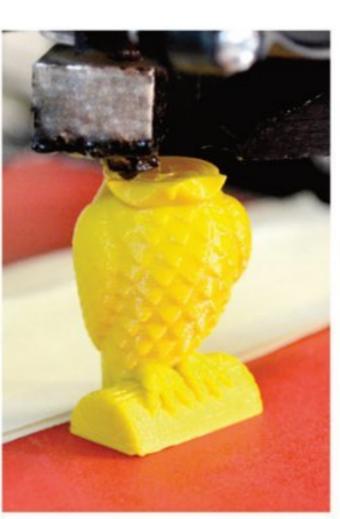
Instead of having to rely on supplies from Earth, astronauts will be able to make objects they need, like tools, parts for experiments, or medical kits. Creating things in space is essential if we want to travel far away from Earth.

Eventually, whole cities in space could be built this way. And delicate objects, which are extremely difficult to create on the ground due to gravity, could be 3-D printed in space and then brought back to Earth.

How does 3-D printing work?

A 3-D printer on Earth normally uses plastic to build objects. The plastic is heated up so that it melts, and this melted plastic emerges from the printer's nozzle, building the object from the bottom upward, layer after layer. As we explore different planets, we will find different materials that we can use for 3-D printing.







3-D-printed owl being made on Earth



Gravity meter This gravity meter was the first

This gravity meter was the first privately funded object to be 3-D printed in space. It is the first of many objects that companies will create in space in the future. A gravity meter is used by astronauts to signal when they reach weightlessness, as it will begin to float freely.

Printed tools

When astronaut Barry "Butch" Wilmore lost his wrench, instead of having to wait for another one to be brought from Earth, he was able to create a new one using a 3-D printer on the ISS.





Barry "Butch" Wilmore holding the 3-D-printed wrench

Future spacesuits



NASA

This spacesuit is called the Z-2. It is being designed by NASA for future missions to Mars. It is lightweight, flexible, and will be able to withstand the harsh environment on the Red Planet. It has adjustable shoulders and waist, so it can fit people of all shapes and sizes!

Spacesuits make the impossible possible. They allow people to survive outside a spaceship on space walks, walk on the moon, and in the future they will enable people to walk on other planets. Spacesuits

SpaceX

This spacesuit is worn by astronauts inside SpaceX's Crew Dragon spacecraft. It is much less bulky than traditional spacesuits, but is not designed to be worn outside a spacecraft.

also have other uses, such as providing protection to astronauts in case of emergencies during launch and reentry to Earth.

As our exploration of space continues, people will go where they have never been before, and will spend more time on places such as the moon. As a result,



Boeing

Here, astronaut Chris
Ferguson is wearing the
Boeing spacesuit, which is
designed to be worn aboard
Boeing's Starliner spacecraft. It
weighs about 20 lb (9 kg), has
a soft helmet and visor attached
to the suit, and comes with
touchscreen-friendly gloves.



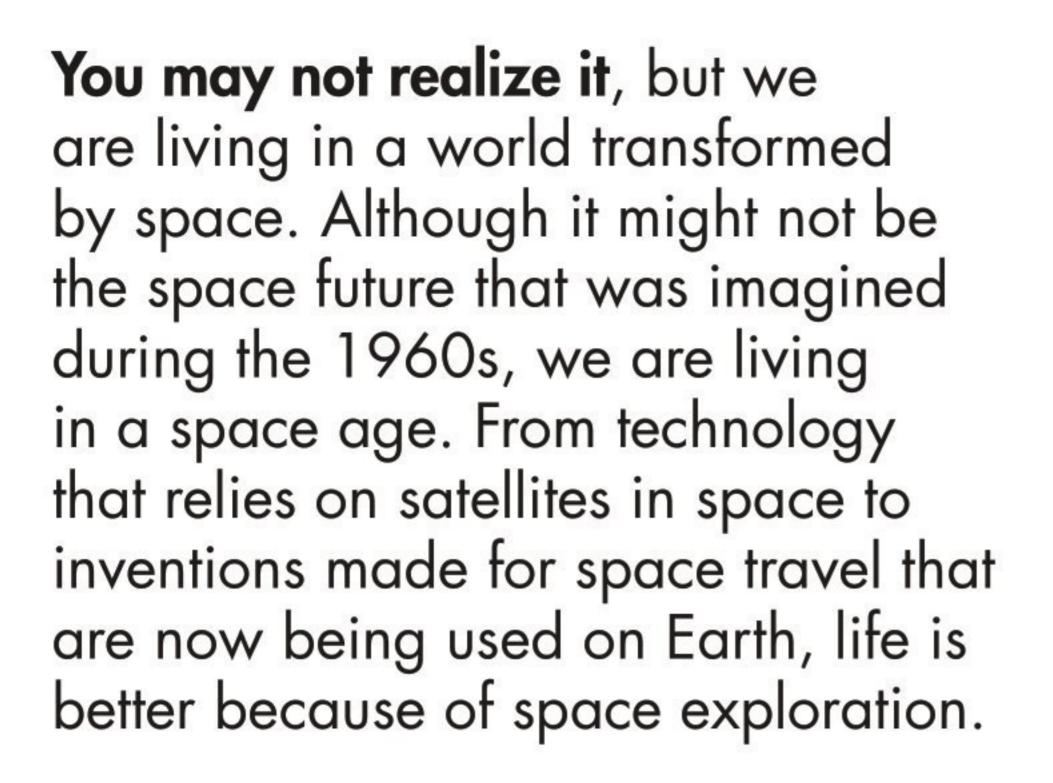
Preparing for dust

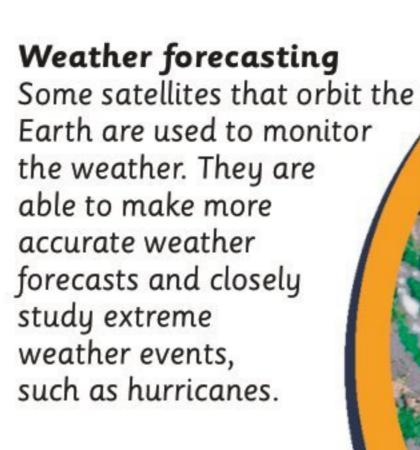


One of the biggest problems for the Apollo astronauts was moon dust. The suits that they wore got extremely dusty, but luckily the longest missions only lasted a few days. When astronauts return to the moon for longer periods of time, they will need to wear suits that are resistant to moon dust.

the spacesuits astronauts wear will evolve.

Modern spacesuits are still bulky, but future advances in technology could change this. Spacesuits of the future might fit better, weigh less, and be easier to move around in, while still providing all the protection that astronauts will need.







NASTRAN

Developed by NASA engineers during the 1960s, NASTRAN software was used to design efficient space vehicles and to do structural analysis. Today, the same software is used to test big structures like airplanes, nuclear reactors, and even roller-coasters.



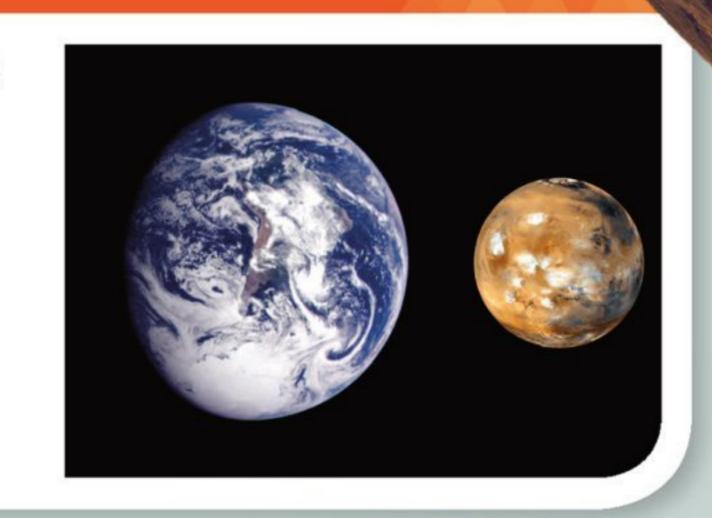
Why Mars?

The next major goal in the human exploration of space is Mars. In the past, this planet was probably much warmer and wetter. We have so many questions about Mars. Did life once exist there? Could life still exist in a simple form? If there was life on Mars, what happened to it? We've been asking these extraordinary questions for many centuries. To find the answers we need a lot of evidence.

While robots have helped us learn more about the Red Planet, they can't replace humans on the ground. If we want to know for sure if life once existed on Mars, the best way to find out is by visiting. And it's not just the possibility of life that's interesting—learning more about the geology of Mars could help us to understand more about how Earth and the other planets in our solar system formed.

Size of Mars

Mars is smaller than Earth and, like Earth, Mars has seasons. A year (the time it takes a planet to travel around the sun) is much longer on Mars because it is farther away from the sun. However, a day (the time it takes for a planet to spin once on its axis) on Mars is similar in length to a day on Earth.



South pole.

In 2018, ESA's Mars Express spacecraft discovered liquid water underneath Mars's south pole.



A mission to Mars isn't going to be easy. There are lots of challenges to overcome—such as radiation from the sun and the effects of long periods of weightlessness on the human body. At the moment, government agencies, including NASA, and private companies are developing ideas for how to send people to the Red Planet.

Earth's position at landing on Mars

Earth

Mars's orbit.

Earth's orbit

Leaving Earth

The crew will say goodbye to their friends and family as they begin their adventure. They may launch in a small spacecraft and meet with a larger vehicle that has been assembled in orbit.

Long journey

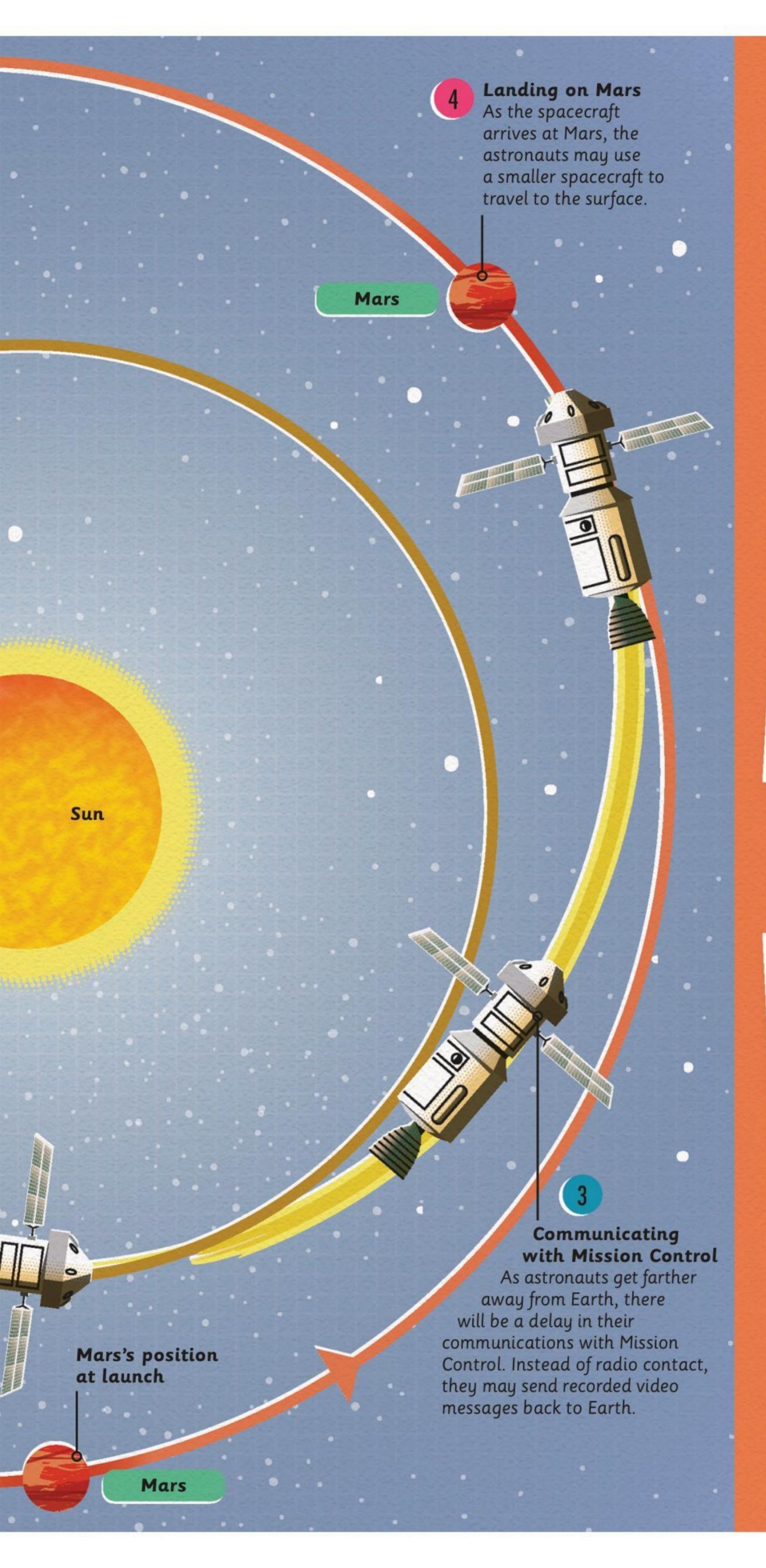
As the crew travel deeper into space, the Earth and the moon will get smaller. They won't get bored they will be busy looking after the spacecraft, exercising, and will have time off to watch movies!



Earth

The journey to Mars

The journey to Mars will take at least six months. At its closest point, Mars is about 34 million miles (54 million km) from Earth. However, in the time it will take to travel there, Earth and Mars will move to different positions as they travel around the sun.



Touchdown

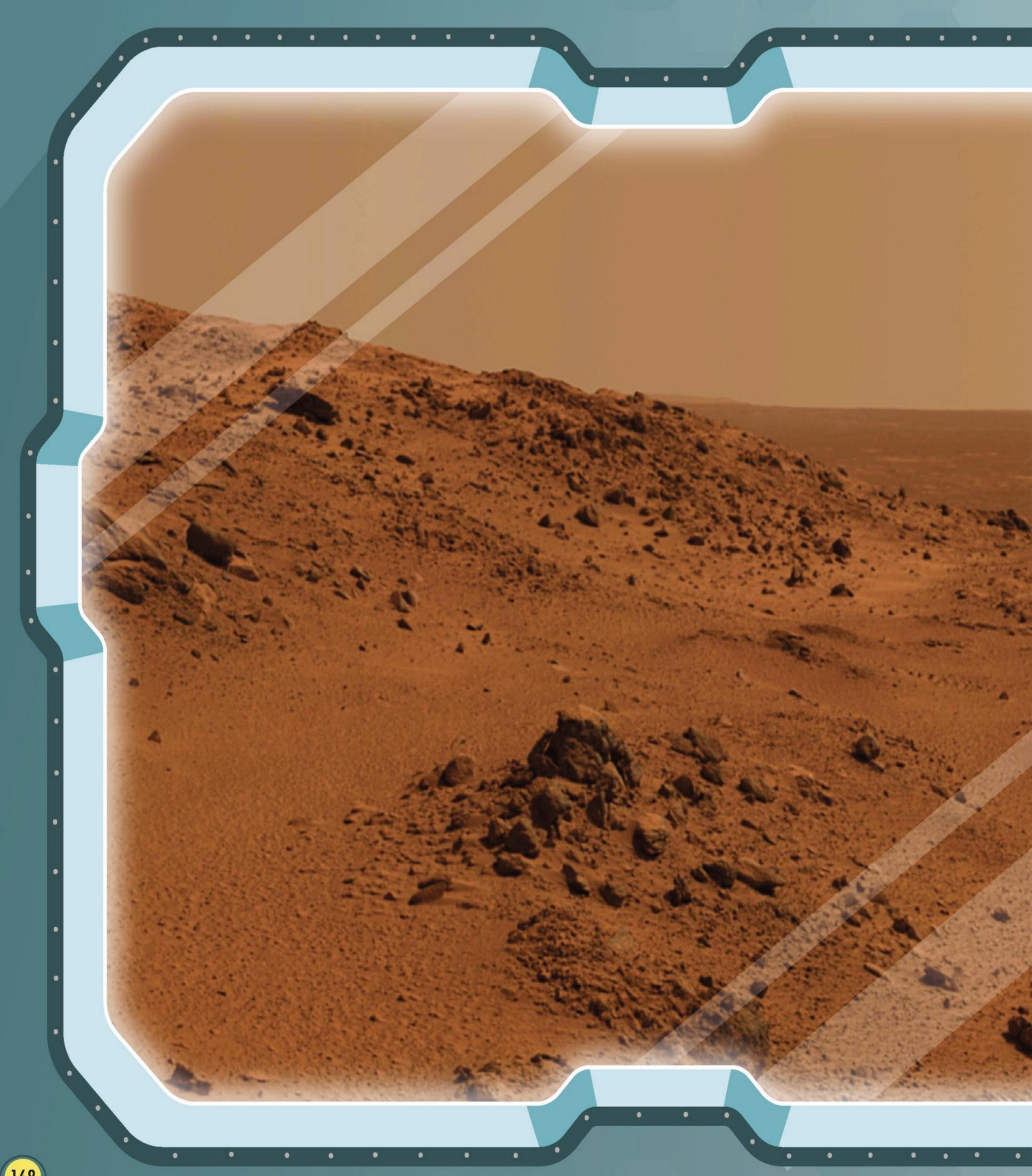
Landing on Mars is extremely difficult, and is nothing like landing on the moon or on Earth. This is because Mars has a thin atmosphere, which makes it hard for spacecraft to slow down on entry. Here are two artist's impressions of SpaceX's Dragon spacecraft landing on Mars.



SpaceX's Dragon spacecraft during landing



SpaceX's Dragon spacecraft after landing



Humans on Mars

Imagine traveling for at least six months across our solar system and seeing Earth getting smaller and smaller until it is just a dot in the sky. You are now farther away from home than any human has ever been in the history of our species. As you and your crew arrive at Mars, you see the dusty red landscape come into view.

Descending through the thin atmosphere, slowed first by a big parachute, then by rockets on your spacecraft, you eventually arrive safely on the surface. It will take you a few days to adjust to Mars's low gravity level, which is around one-third of Earth's gravity. Then, the time comes to put on your spacesuit, open the door of your spacecraft, and take the first steps on another planet.

Just as when Neil Armstrong and Buzz Aldrin set foot on the moon, millions of people back on Earth will be watching as your boot touches the soil. You are now the first person

to set foot on another planet. What would your first words be?



Sunset on Mars

On Mars the sky is pink-red, but the sunsets are blue. This photo was taken by the Curiosity rover, but one day people will get to witness these blue sunsets with their own eyes.

Living on Mars

One day, humans will live and work on Mars. However, unlike going to the moon, a mission to Mars will result in more than just flags and footprints being left behind.

The goal is to have a permanent and continually occupied base on Mars. This base will be our first outpost on another planet, and will act as a stepping stone to help us explore even deeper into space. It will also bring us one step closer to becoming a multiplanetary species.

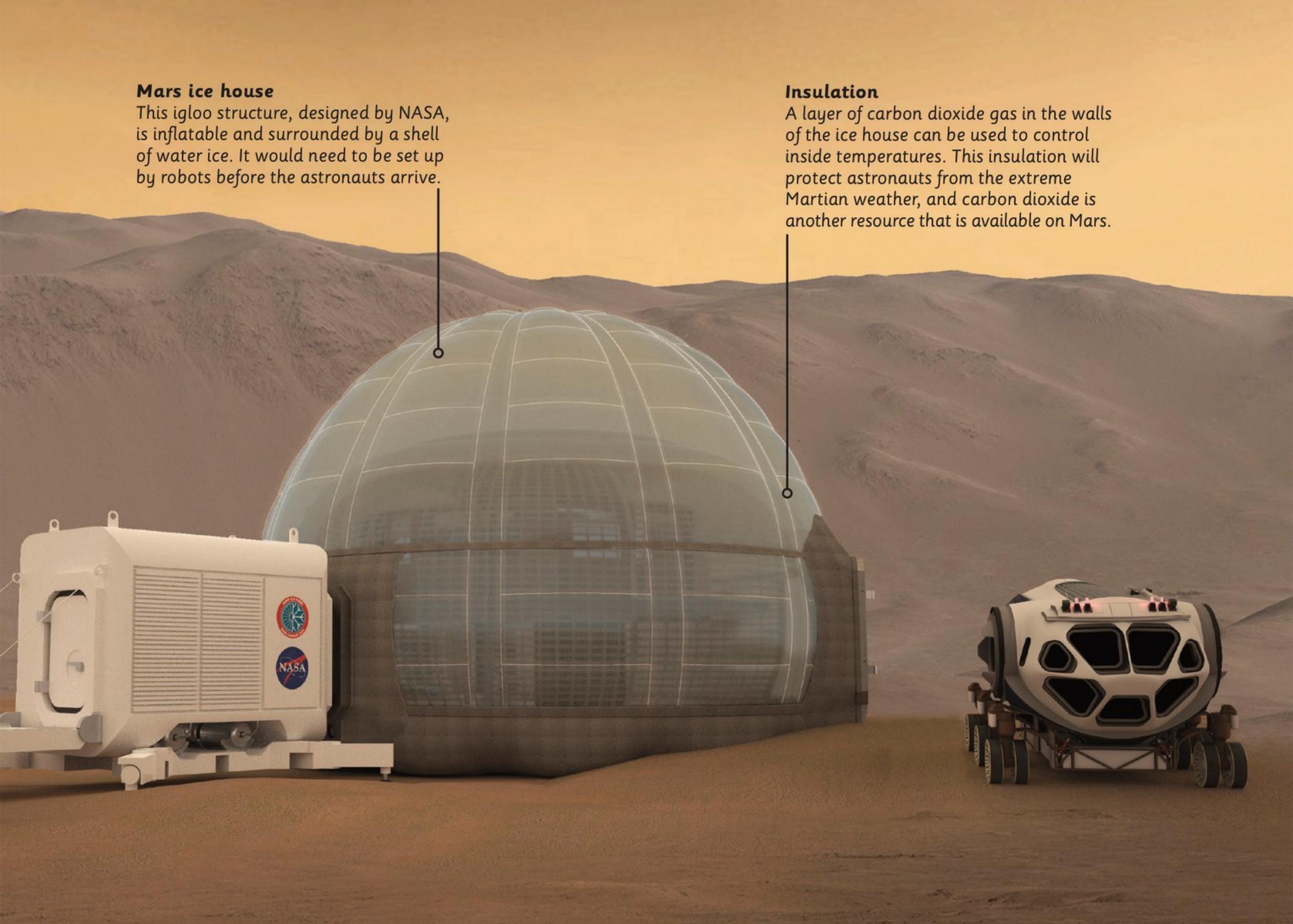
When we explored new places on Earth, we adapted to the land. We will need to do the same on Mars and use existing Martian resources to survive—this process is called "in-situ utilization." One of the most important resources on Mars is water ice. This could be used to make fuel, and even to make houses for astronauts to live in. Water ice could help protect astronauts from the dangers of radiation on the planet. The technology we need to do this is already being developed.



Growing food on Mars

Farming is important for space exploration because astronauts will need to grow food to survive away from Earth. As well as being a source of food, plants will also help to support the environment of a Mars base, converting the carbon dioxide we breathe out into the oxygen we need to breathe in.





Are we alone?



Energy

Life on Earth would not be possible without the sun, which is a constant source of energy.

Our planet

Earth is unique because it is the only place where we are certain that life exists.

Raw materials

Raw materials needed for life are found all over Earth—for example in soil.

Earth from far away

If a powerful planet-hunting telescope from far away was pointed at Earth, this is what it would look like.

Enceladus

A frozen moon of Saturn, Enceladus is believed to have a liquid ocean underneath its icy surface.

Studying Earth

The universe is gigantic and there are lots of places we could look for life. Understanding more about the Earth, including the extreme places life can exist—such as deep beneath the ocean — helps to focus the search of where to look in space.

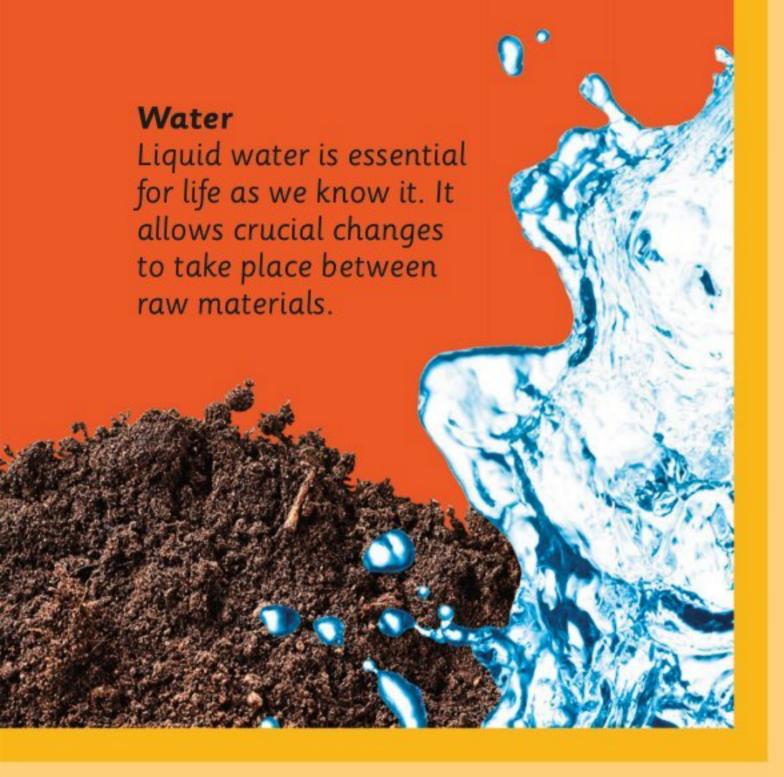
Europa

Orbiting around Jupiter, Europa has an icy surface with evidence of a liquid ocean beneath it.



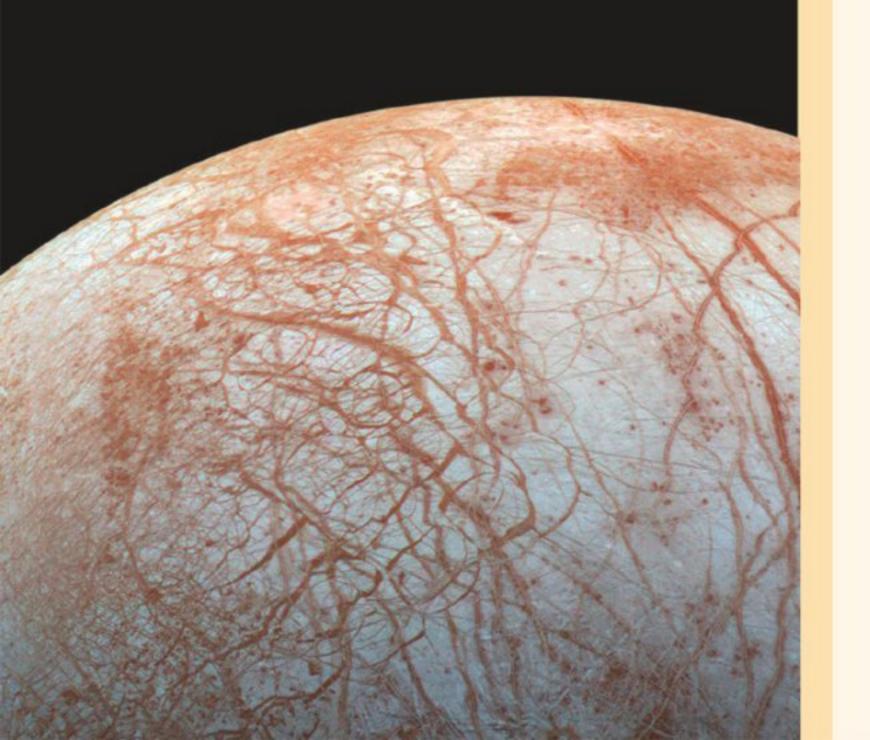
What you need for life

In order for life as we know it to exist, you need three basic ingredients: an energy source, liquid water, and raw materials — such as oxygen, nitrogen, and carbon. Scientists look for these three things when looking for life elsewhere.



Life within our solar system

Even if we don't discover life on Mars, there could still be life elsewhere in our solar system. Among the places scientists are looking are the moons around other planets.



One of the biggest questions we have yet to answer is, "Are we alone?" At the moment, the only life we know of is here on Earth. We have not yet discovered aliens, and as far as we know, aliens have not discovered us!

We think it's unlikely that we are completely alone. Life can exist in some extreme places on Earth, and we also know that there are lots and lots of other planets in the universe. But until we find life—or it finds us—we won't know the answer for sure.

There may even be life elsewhere within our solar system. If this is confirmed, it would mean that life would have developed by itself more than once in our solar system, and that it is far more likely that life has evolved elsewhere in the universe. Just imagine what else is out there.

"During this century, we will explore moons and planets in our solar system with robots and humans, looking for life."—Jill Tarter, scientist searching for extraterrestrial intelligence at the SETI Institute

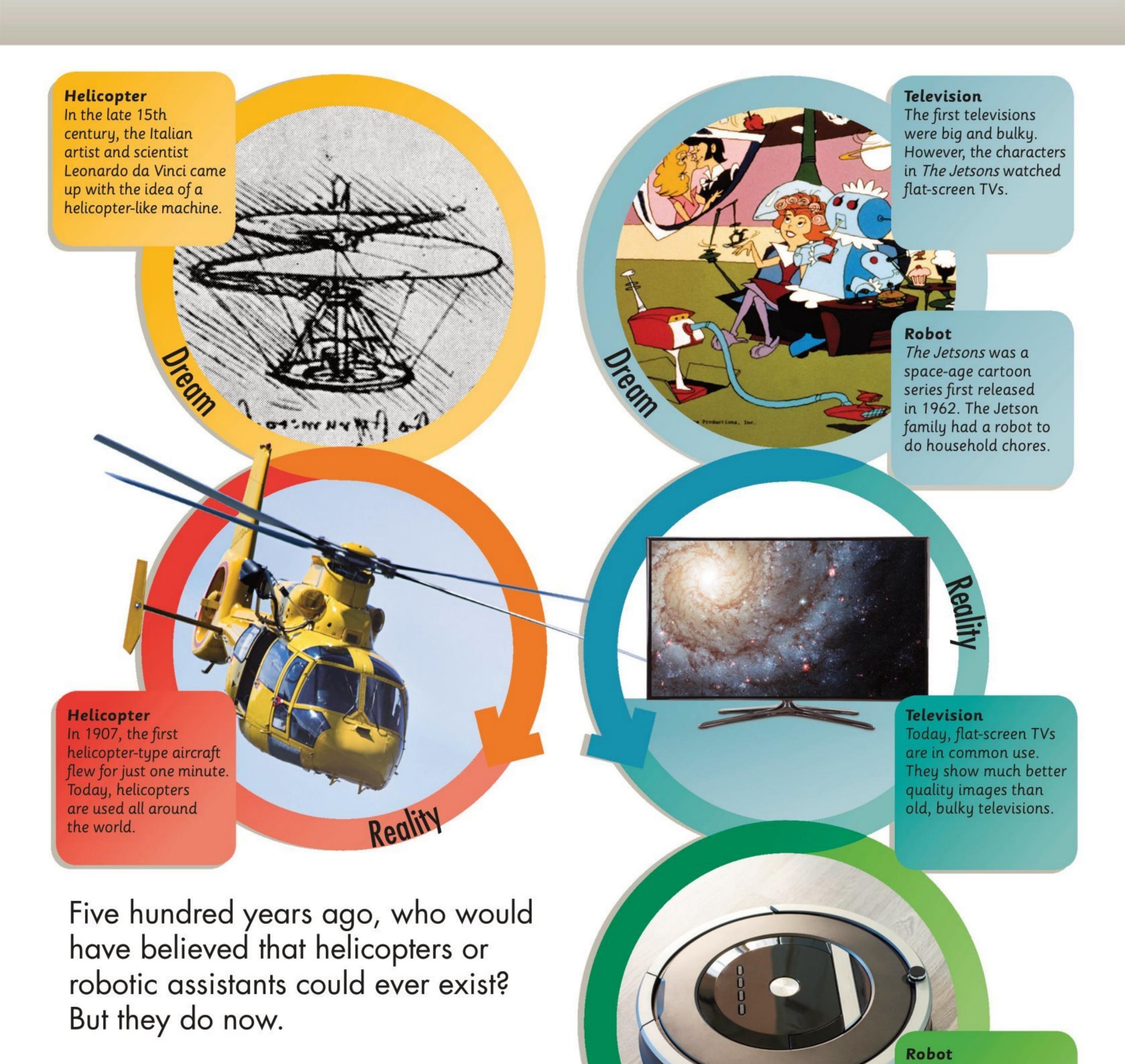
Science nonfiction



For a long time, people have been dreaming up crazy ideas for the future. Sometimes these ideas came true! In fact, science fiction could be renamed "science prediction," because many of the things that people have imagined eventually turn into reality.

Sci-fi writers, scientists, and artists often think of things long before they happen. Whatever you dream up may seem impossible now, but it doesn't mean it always will be.

Some of the ideas imagined in the past were made fun of at the time.



The reality of these ideas isn't always exactly how people imagined, but that's part of the excitement, too!

This robotic vacuum cleaner can whizz around your house, cleaning your floors while you relax.

Reality

$\leftarrow \rightarrow \triangle$

Space jobs

There are lots of different jobs in the space industry—you don't just have to be an astronaut. Many thousands of people work from Earth to support both human and robotic missions.

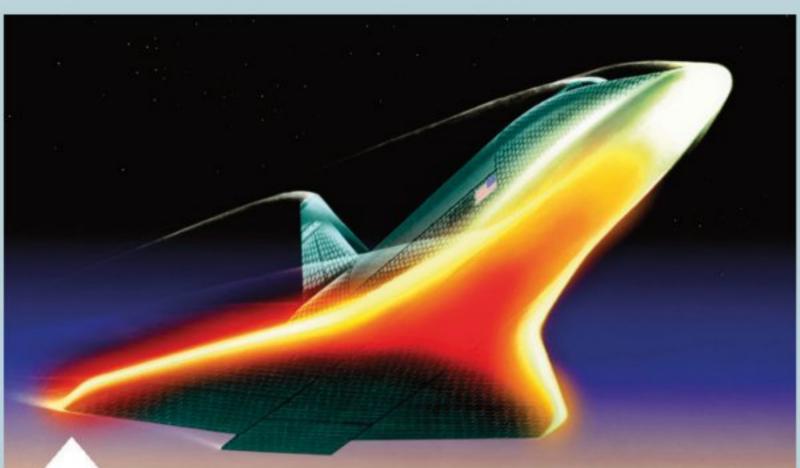
In the future, as we explore deeper into space, there will be a lot of different jobs to do. We will need engineers to build space robots, travel agents to help book vacations in space, and doctors to help space travelers stay healthy.

The type of people who can go into space will also change. We will



WE WANT YOU!

need to take
people who are
good at building
and growing
food. To make
sure future space
missions are
successful they
will also need
to get along well
with others.



Spacecraft designer

Imagine being able to design spacecraft for missions to the moon, Mars, or perhaps even an asteroid. People already have jobs designing both robotic spacecraft and ones that can carry astronauts. As we travel deeper into space, skilled engineers and designers will be needed to create the next generation of spacecraft that is able to take on new challenges.



Teacher

Every astronaut was inspired by a teacher, and today aboard the ISS astronauts work with teachers back on Earth to help show children how exciting space travel is. Teaching others about space and STEM (science, technology, engineering, and math) subjects is vital if we are to continue exploring. One day, in the future, classes may even be held in orbit around the Earth, on the moon, or even on Mars!





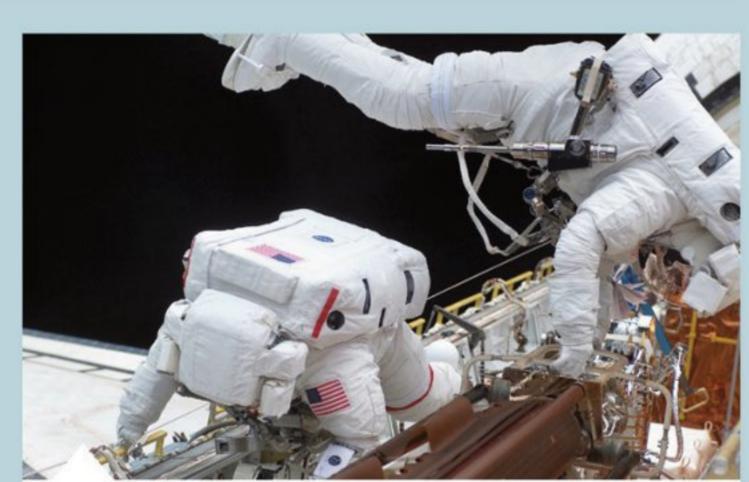
Find a job





Farmer

Future astronauts — particularly those who travel a long way from Earth — won't be able to rely solely on supplies. Having someone who is skilled at growing food will be vital for future space missions. One of the most important skills they will need to have is to be able to grow crops in extreme environments — such as on the moon or in microgravity.





Astronauts were required to do space walks to build the ISS, and they still do space walks to carry out repairs. As humans go to the moon and then Mars, they will need to take people with building skills with them — to help construct future bases.

An interview with a Virgin Galactic test pilot



Kelly Latimer (center)

Name: Kelly Latimer Job title: Virgin Galactic test pilot

Q. How did you get your job?

A. Before this job, I flew as a test pilot in the Air Force, with NASA, and then at Boeing. I had a lot of flight-test experience in many different aircraft, which helped me to get this job with Virgin Galactic.

Q. What is so exciting about your job?

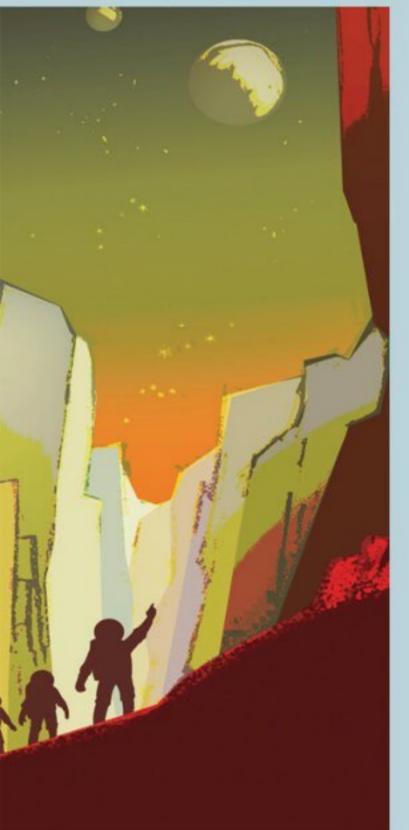
A. The possibility to go to space... a lot!

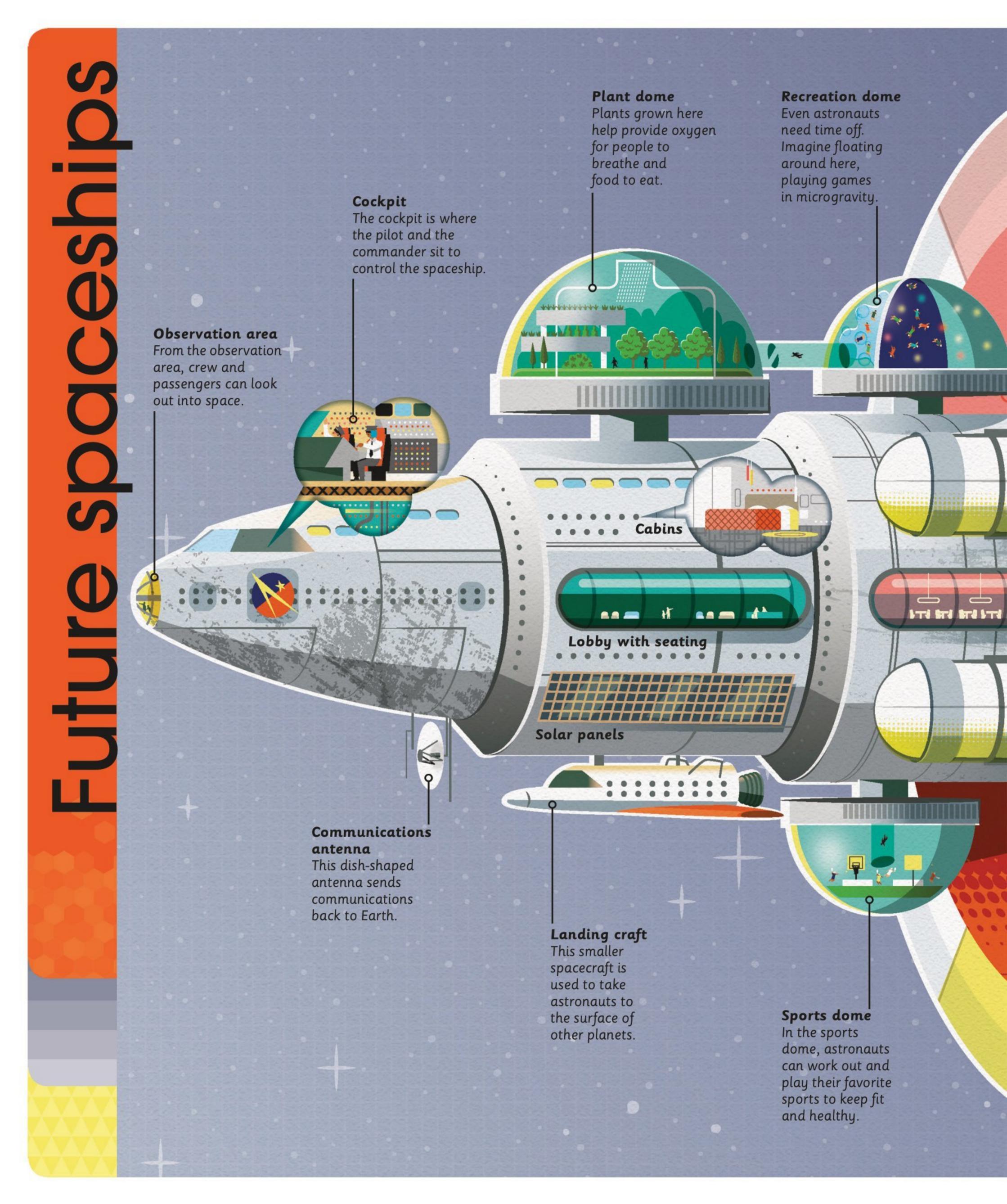
Q. How do I get a job like yours?

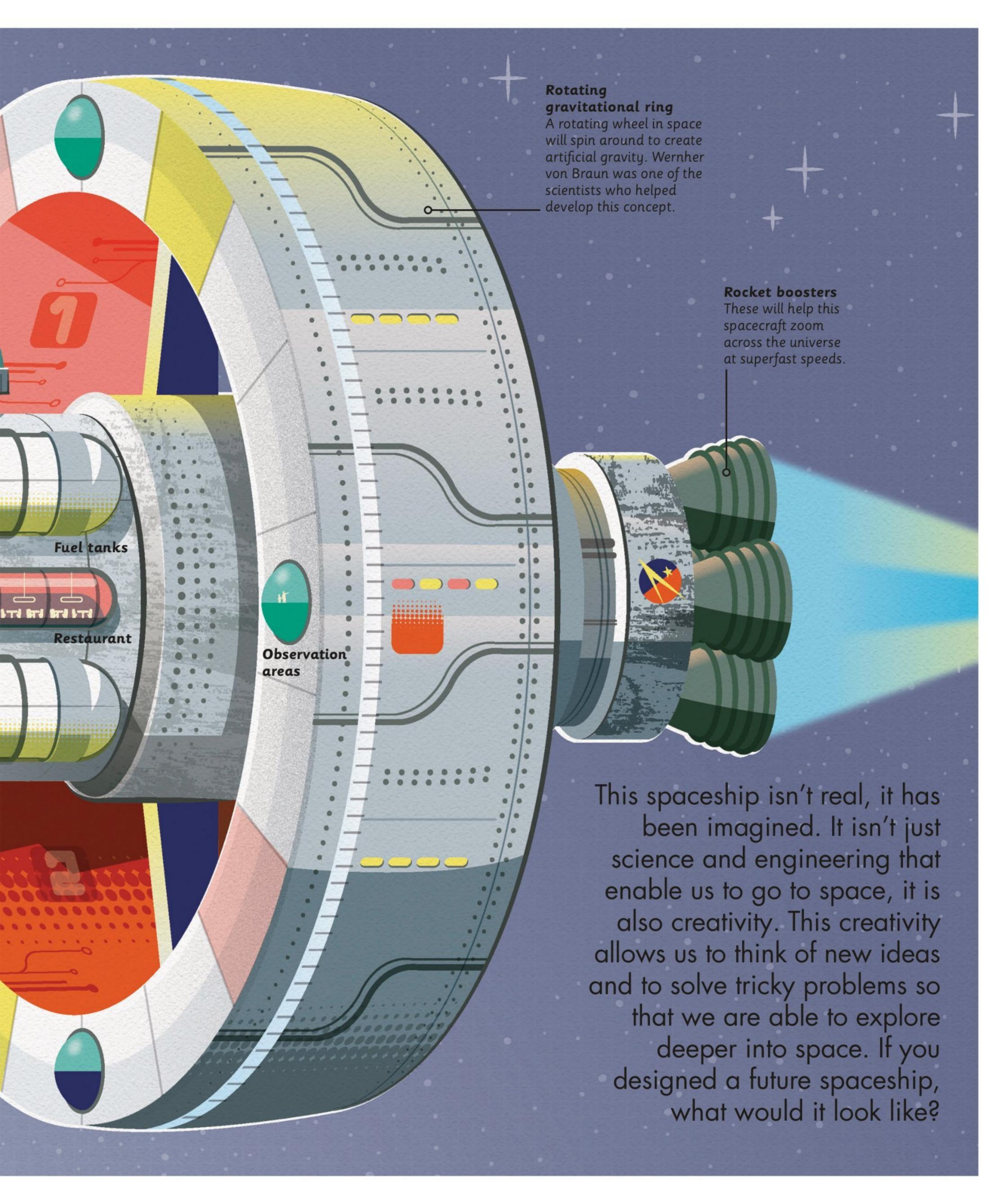
A. It is important to get a good education, especially in math and science. Then you need to have a lot of flying time in as many different airplanes as you can.

Q. What are your hopes for the future of space tourism?

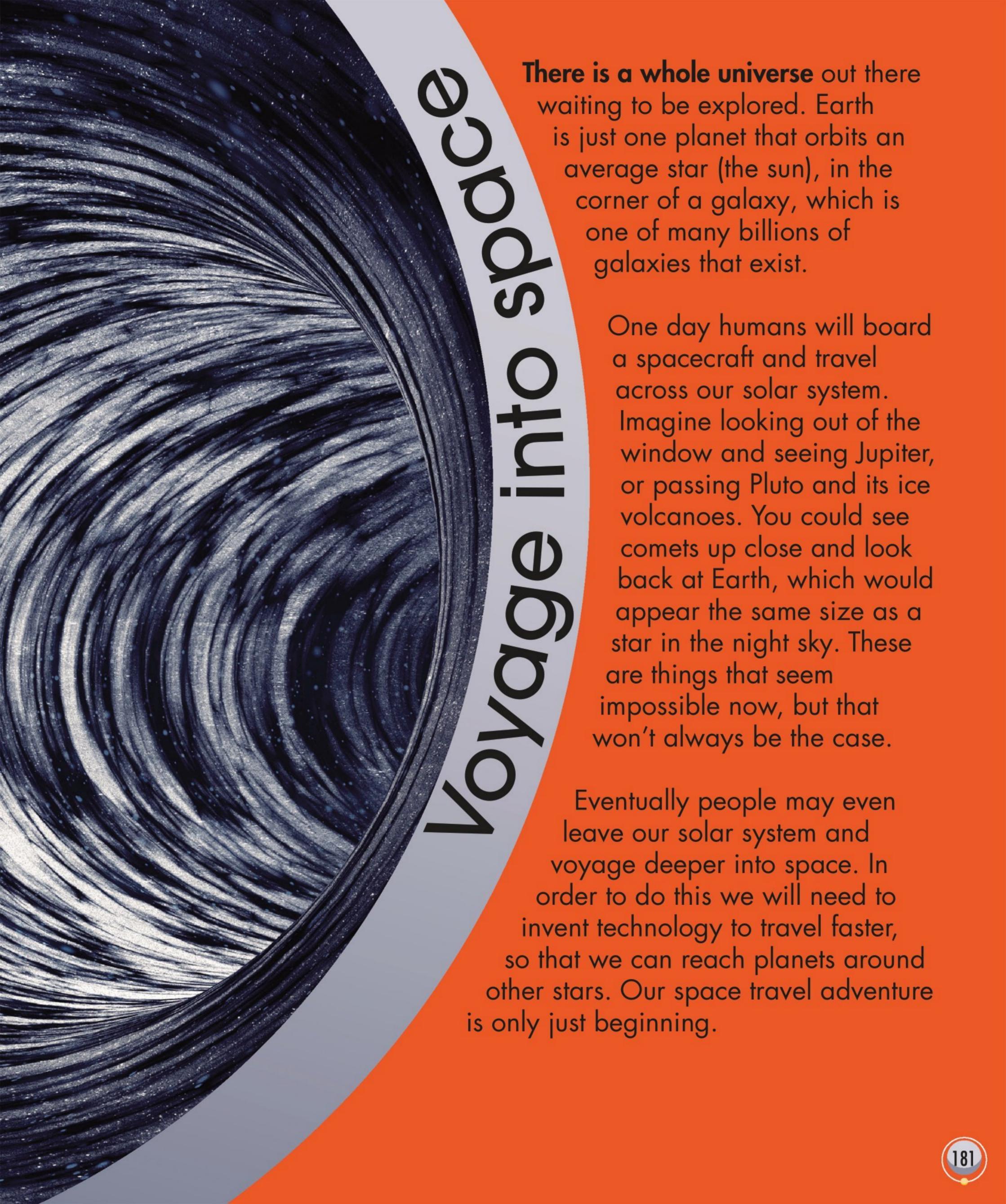
A. At the moment, space tourism is something extraordinary that we are still working to achieve. I hope someday it is just a normal trip that everyone gets to take. I also hope it leads to more space exploration.











Looking after Spaceship Earth

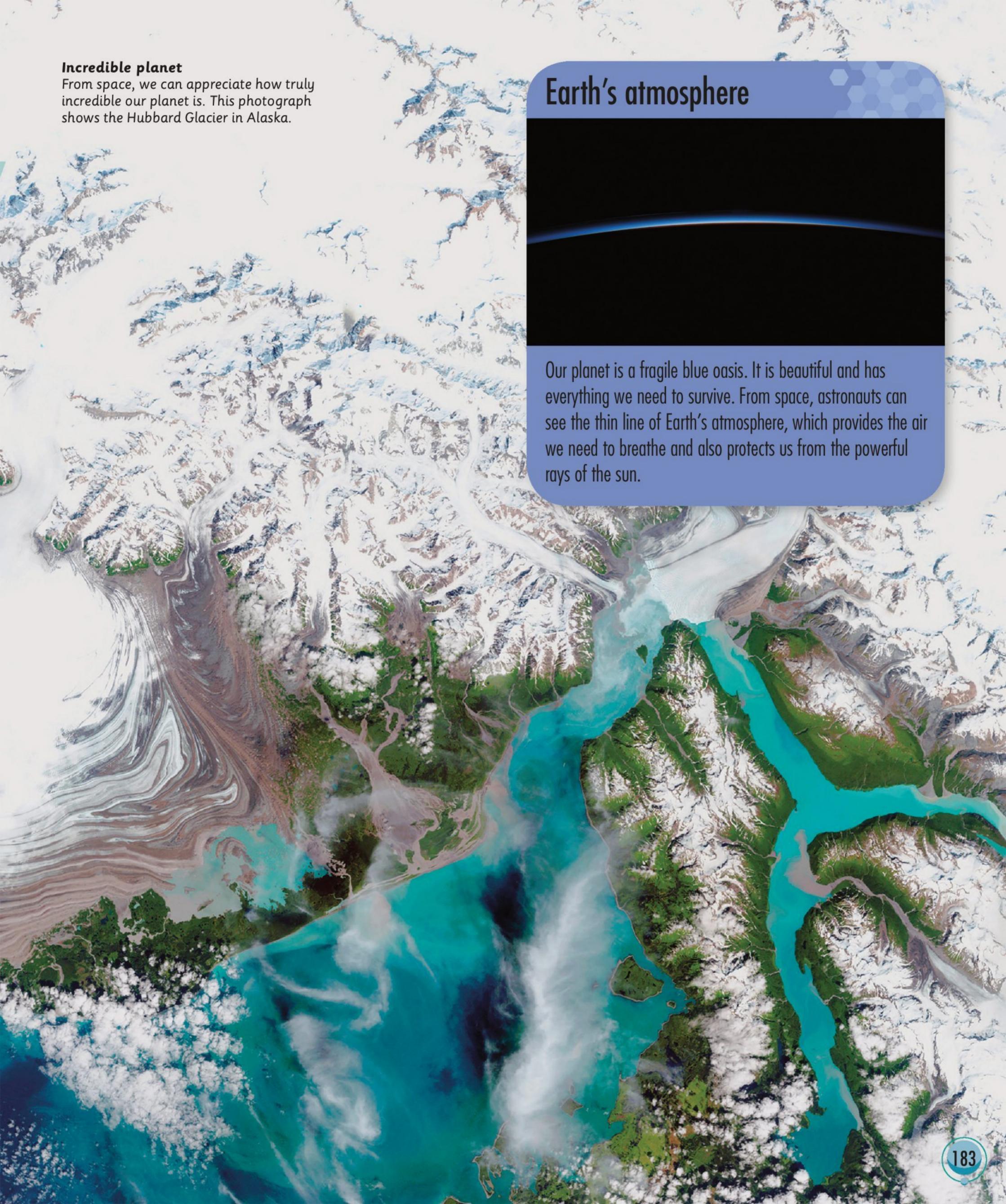
No matter where we go in space, Earth will always be our home.

When you really think about it, planet Earth is like a spaceship—and we are the passengers! More than 7 billion people, plus all other living things, share our spaceship home.

Space exploration is teaching us a lot about Earth. The satellites we've sent to space show us how the climate of our planet is changing, and it's not good news. Temperatures are rising faster than normal. This is because there are more harmful gases in the atmosphere as a result of pollution and forests being chopped down.

Traveling into space is the most significant thing humans will do as a species. Not just because of the adventure, but also because it changes our view of Earth. One day, people may live on other planets. However, Earth will always be our home. We all need to look after Spaceship Earth.





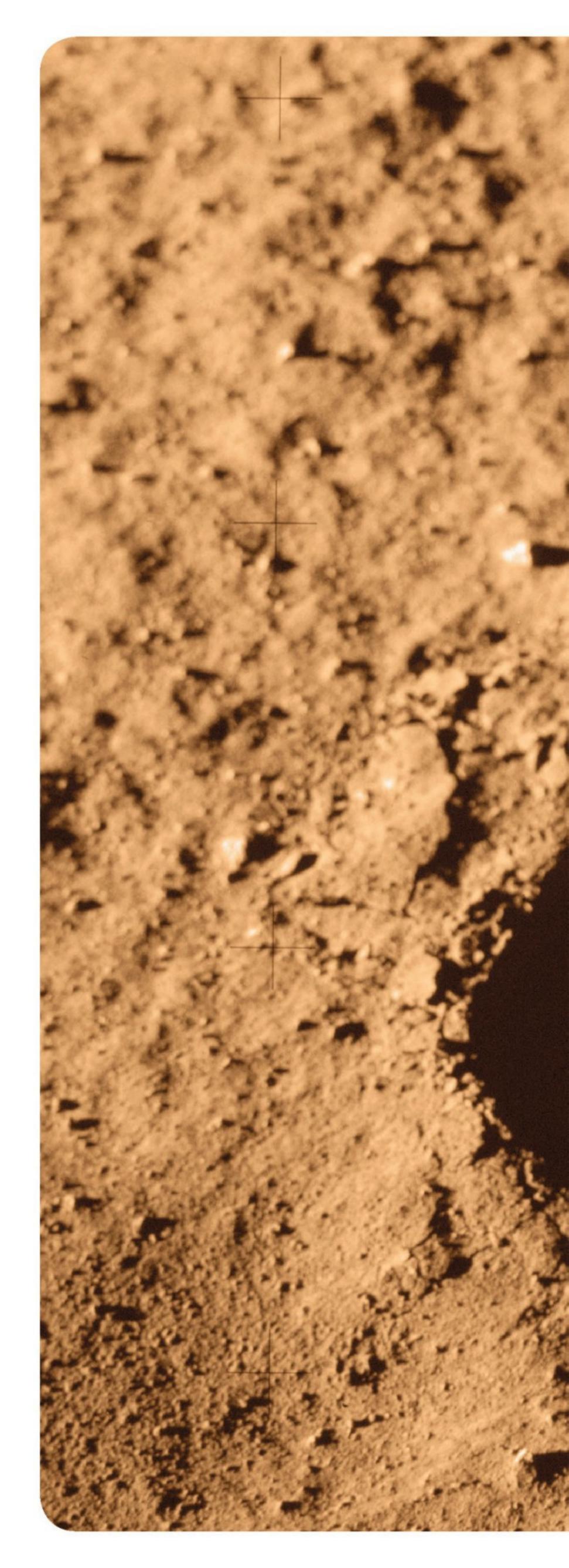
Throughout history, humans have achieved things they once thought were impossible. Barely more than a century ago, to fly was just a dream. Since then, 12 people have walked on the moon. Now, we mostly take flying for granted—and anyone born after November 2000 hasn't known a time when there weren't people continuously living and working in space.

As the rate of technology advances ever faster, so will our adventures in space. The universe is yours to be discovered. It is not only as strange as you can imagine, it is stranger than you can imagine!

Humans will, in your lifetime, return to the moon and then travel onward to Mars. In fact, the first person to walk on Mars is probably in school right now.

In the words of Eugene Cernan, the last person to walk on the moon: "Dream the impossible and go out and make it happen. I walked on the moon—what can't you do?"

To be continued...





Glossary

airlock

Small, sealed room where astronauts can enter or exit a spacecraft or space station

artificial

Created by humans

asteroid

Rocky object that orbits, or travels around, the sun

astronaut

Human space traveler

atmosphere

Layer of gas that surrounds a planet

booster

Small rocket attached to a larger rocket to produce extra power during launch

comet

Object made of ice and dust, which develops a tail as it travels near to the sun

Command/Service Module (CSM)

Crew cabin of the Apollo spacecraft, where astronauts lived and worked during their journey from the Earth to the moon

cosmonaut

Russian equivalent of an astronaut

crew

Group of people who work on a spacecraft

dock

When a spacecraft joins with another spacecraft or space station in space

dwarf planet

Object that orbits the sun, but which is too small to be classified as a planet

ESA

European Space Agency

exoplanet

Planet that orbits a star other than the sun

galaxy

Huge group of stars, dust, and gas held together by gravity

gravity

Force that pulls objects toward each other

Kuiper Belt

Ring of ice and rock that is beyond Neptune

laboratory

Place where science experiments are done

launch

Process of using rockets to send something into space

luna

Word that relates to the moon

Lunar Module (LM)

Part of the Apollo spacecraft that landed on the moon

meteorite

Piece of rock, metal, or ice that lands on a planet or moon's surface

microgravity

When the force of gravity is present, but its effect is small. Microgravity causes objects to become weightless in space

Milky Way

Galaxy we live in

module

Part of a space station that can be connected to other parts

moon

Object that orbits a planet or asteroid

NASA

US space agency. NASA stands for National Aeronautics and Space Administration

nebula

Cloud of dust and gas in space where stars are born

orbit

Path an object takes around another when pulled by its gravity—for example, the moon orbits the Earth

payload

Cargo carried into space by a rocket. It may include supplies, spacecraft, or satellites

planet

Large, spherical object that orbits a star

probe

Uncrewed robotic spacecraft designed to study objects in space and send information back to Earth

radiation

Rays of energy, which can be harmful

Red Planet

Nickname of the planet Mars, because of its red-colored, rusty soil

rendezvous

Meet up at an agreed time and place

rocket

Machine that can propel itself into space

rover

Vehicle that is driven on the surface of a moon or a planet that is not Earth

satellite

Object that orbits another larger object

simulation

Controlled test of a situation that might be encountered — for example, doing experiments on the moon

solai

Word that relates to the sun

solar system

The sun and everything that orbits it

space station

Large spacecraft where astronauts live and do experiments

spacecraft

Vehicle that travels in space

spacesuit

Specially designed sealed clothing worn by an astronaut to protect them in space

space walk

When an astronaut in space is outside a spacecraft, usually to repair or test equipment

star

Huge, glowing sphere of gas, such as the sun

telescope

Tool used to look at faraway objects

test pilot

Pilot who flies aircraft to test that they work

tether

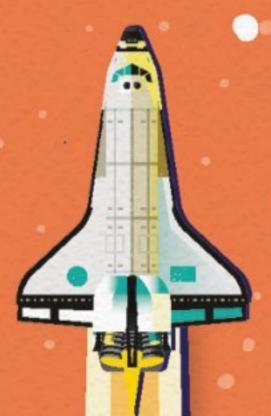
Cord that attaches an astronaut to a spacecraft during a spacewalk

universe

All of space and everything in it

wormhole

Theoretical passage in space that can connect two places that are large distances apart



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Sarah Cruddas is a British space journalist, broadcaster, and author with an academic background in astrophysics. She is a regular face on TV in the UK, as well as writing and speaking globally about why space exploration matters. Sarah believes that the exploration of space is the most significant thing we will ever do as a species and hopes to inspire the next generation of scientists, engineers, and astronauts.

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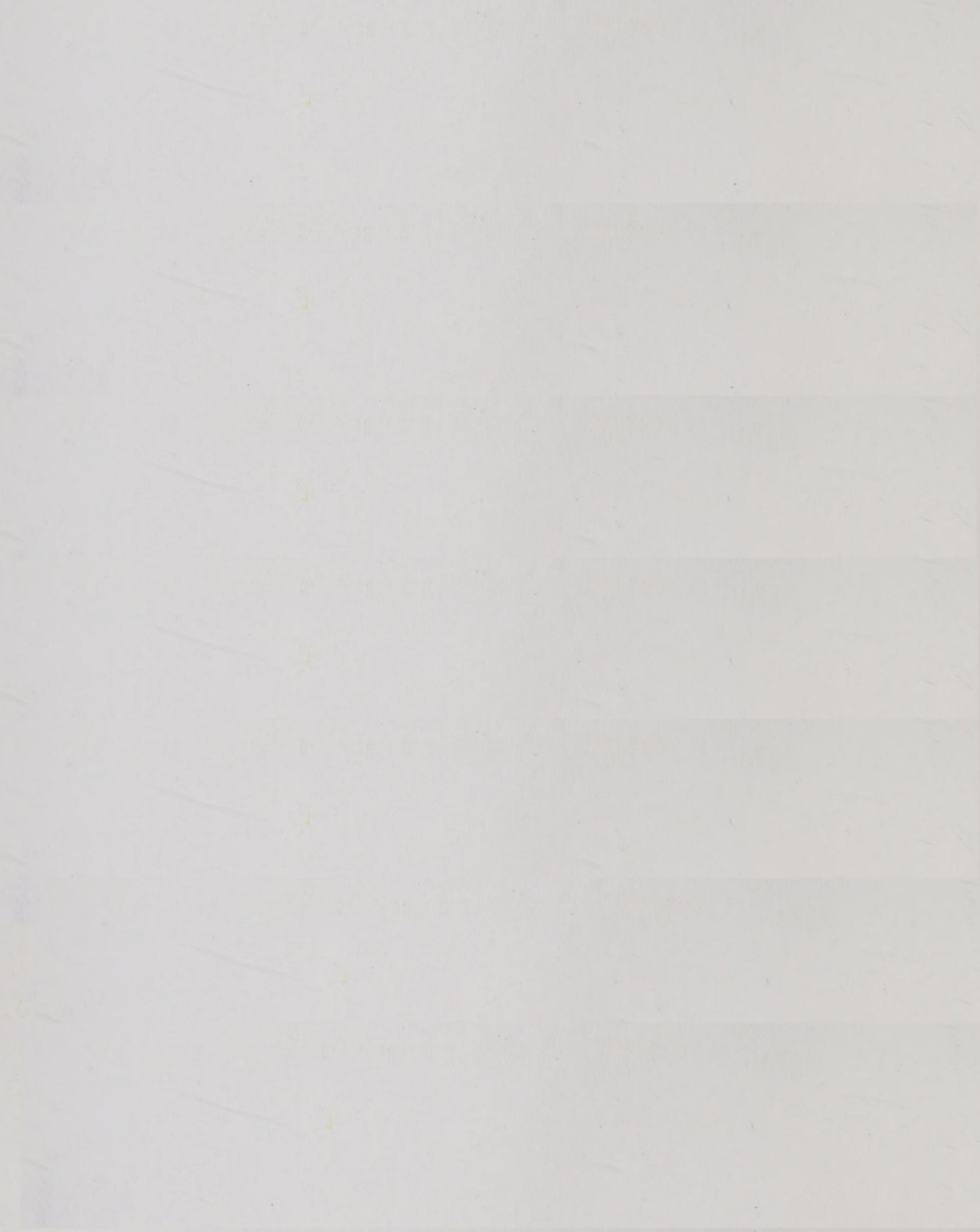
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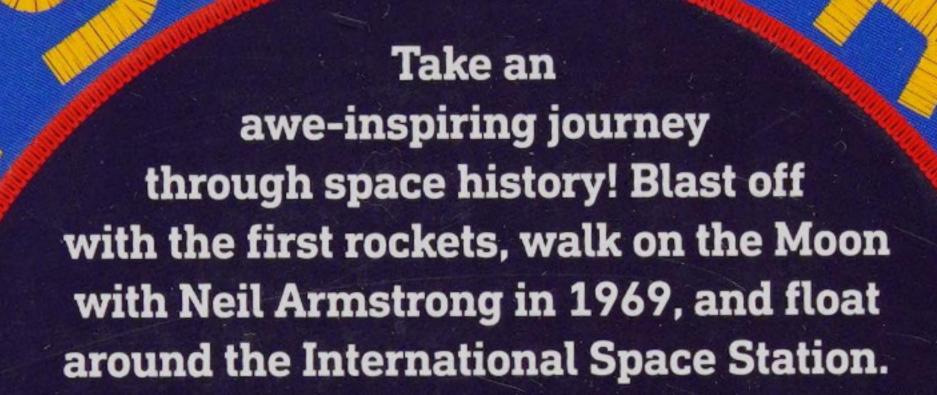
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